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AMINO DERIVATIVES OF ZIRCONIUM TETRABROMIDE—PART I

By

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ABSTRACT

The amino derivatives of zirconium tetrabromide have been prepared by the action of some mono and diamines on $ZrBr_4$ in ethyl acetate, their properties and structures discussed.

INTRODUCTION

Several ammoniates of $ZrCl_4$ of the composition $ZrCl_4 . x NH_3$ (where $x = $ 2, 3, 4 and 8) are reported in the literature. By the action of NH_3 on $ZrCl_4$ under different exprimental conditions Paykull[1] obtained the tetrammine, Matthew[2], the di-, tetra- and octammines and Stähler and Denk[3] the octa- and triammines. Metthew[2] studied the action of methyl, ethyl and propylamines, toluidine, pyridine and β-naphthylamine on $ZrCl_4$ and found that one molecule of $ZrCl_4$ combined with two molecules of pyridine and β-naphthylamine and four molecules of the rest. With $ZrBr_4$ he[4] obtained the compounds $ZrBr_4.4C_2H_5NH_2$, $ZrBr_4.4C_6H_5$ NH_2, $ZrBr_4.4NH_3$ and $ZrBr_4.2C_5H_5N$. Fowles and Pollard studied the action of $ZrCl_4$ with NH_3 tensimetrically at low temperatures and observed the formation of several ammoniates, $ZrCl_4.8NH_3$ being the stablest, which on heating at 180°C gave the diammine, further heating at higher temperatures led to the decomposition of the molecule.

A general survey of the literature shows that no systematic work has been done on the formation of compounds of $ZrBr_4$ with amines. The present investigation was, therefore, undertaken with a view to studying the formation of these compounds in ethyl acetate medium.

EXPERIMENTAL

The amines used were of Merck's or B. D. H. pure quality. Ethyl acetate was dehydrated and redistilled. $ZrBr_4$ was prepared by passing bromine over a heated mixture of ZrO_2 and sugar charcoal and excess of bromine removed by passing dry CO_2. It was extracted with ethyl acetate and filtered. The filtrate was

Primary Monoamines

	Compound formed	Colour	% Zr. found	% Zr. calc.	% Bromine found	% Bromine calc.	% Orgnic matter found	% Orgnic matter calc.	% Nitrogen found	% Nitrogen calc.
1. Aniline	$Zr (C_6H_5NH_2)_4 Br_4$	Grey	11·58	11·67	39·77	40·85	48·86	47·48	7·35	7·15
2. o-Anisidine	$Zr (OCH_3.C_6H_4.NH_2)_4 Br_4$	Ash colour	10·99	10·10	36·08	35·42	52·93	54·48		
3. p-Anisidine	Do	Grey	10·96	10·10	35·98	35·42	53·06	54·48	4·169	4·017
4. α-Naphthylamine	$Zr (C_{10}H_7NH_2)_2 Br_4$	Violet	12·91	13·07	44·27	45·89	42·82	41·04		
5. β-Naphthylamine	Do	Ash colour	13·12	13·07	46·00	45·89	40·88	41·04		
6. o-phenetidine	$Zr (OC_2H_5.C_6H_4.NH_2)_4 Br_4$	Dark Brown	10·08	9·51	34·02	33·36	55·90	57·13		
7. Benzylamine	$Zr(C_6H_5.CH_2NH_2)_4 Br_4$	White	10·91	10·86	38·78	38·13	50·31	51·01		
8. o-Toluidine	$Zr (CH_3.C_6H_4.NH_2)_4 Br_4$	Ash colour	10·87	10·86	39·72	38·13	49·31	51·01		
9. p-Toluidine	Do	Light Yellow	10·998	10·86	39·82	38·13	49·182	51·01		
10. m-Toluidine	Do	Amethyst colour	11·18	10·86	41·66	38·13	47·16	51·01		

Primary Diamines

|	Amine	Compound formed	Colour	% Zr. found	% Zr. calc.	% Bromine found	% Bromine calc.	% Organic matter found	% Organic matter calc.	% Nitrogen found	% Nitrogen calc.
1.	o-Tolidine	$Zr (NH_2.CH_3.C_6H_3—C_6H_3.$ $CH_3.NH_2)_2 Br_4$	Dark Grey	11·07	10·92	37·72	38·31	51·21	50·77		
2.	o-Dianisidine	$Zr (NH_2.OCH_3.C_6H_3—C_6H_3.$ $OCH_3.NH_2)_2 Br_4$	Grey	10·09	10·14	36·23	35·58	53·20	54·28	6·103	6·227
3.	Phenylhydrazine	$Zr (C_6H_5.NH.NH_2)_4 Br_4$	Light brown	14·58	14·015	50·82	51·01	34·60	34·975	7·398	7·188
4.	Benzidine	$Zr (NH_2.C_6H_4.C_6H_4—NH_2)_2$ Br_4	Dark grey	11·89	11·70	40·69	41·07	48·62	47·23		
5.	o-Phenylenedia-mine	$Zr [C_6H_4(NH_2)_2]_2 Br_4$	Brown	14·45	14·54	50·60	51·01	34·95	34·45		
6.	p-Phenylenedia-mine	Do	Grey	14·62	14·54	50·77	51·01	34·61	34·45		

analysed for purity (Analysis confirmed the purity of the product : Found $Zr = 22.06\%$ $Br = 77.68\%$, calculated for $ZrBr_4$, $Zr = 22.19\%$ and $Br = 77.81\%$) and used in all the experiments.

A dilute solution of the amine in ethyl-acetate was added to $ZrBr_4$ solution with constant shaking till the precipitation was complete and the amine was in slight excess. It was filtered and the precipitate washed till the washings did not give any precipitate with $ZrBr_4$ solution. All these operations have been carried out in a dry atmosphere. The precipitate was pressed between the folds of filter paper and finally dried in vacuum desiccator.

Bromine was estimated by Piria and Schiff's method and zirconium as ZrO_2. In a few cases nitrogen was estimated by Kjehldal's method and the percentage of the organic matter calculated. In the rest it was found by difference.

GENERAL PROPERTIES

Almost all the compounds are coloured, semicrystalline powders, insoluble in ethyl acetate, ether and benzene, but sparingly soluable in alcohol. The compounds formed with phenylhydrazine, and benzylamine are, however, sparingly soluble in benzene. These compounds are fairly stable in dry atmosphere, but decompose when exposed to moist air for a long time. When treated with water the compounds with mono-amies hydrolyse readily, but those with diamines slowly. They are soluable in dilute acids and decompose with sodium hydroxide into the corresponding amine, zirconium hydroxide and sodium bromide.

$$Zr (4 \text{ amine}) Br_4 + NaOH \rightarrow Zr (OH)_4 + 4NaBr + 4 \text{ amine}$$
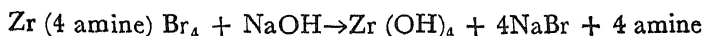
All these compounds are stable towards heat upto about 150°C. but when heated at higher temperatures they decompose without melting except those obtained with benzylamine and phenylhydrazine which melt at 214°C and 180°C respectively. When heated alone a sublimate deposits on the cooler part of the test tube, which gives the test for amine and bromide, but when heated with soda-lime only the amine sublimes.

DISCUSSION

The maximum covalency that Zirconium can exhibit is 8 and in all the compounds studied four molecules of a monoamine and two molecules of a diamine are co-ordinated with one molecule of Zirconium tetrabromide except in the case of α - and β Naphthylamine when only two molecules combine with one molecule of Zirconium tetrabromide, which is probably due to steric hinderance. It appears that the amines attach themselves to the central atom, chelate compounds being formed, in the case of diamines, which is probably responsible for the greater stability of these compounds. The E. A. N. does not assume the inert gas configuration and therefore the compounds are not very stable.

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PHYSICO-CHEMICAL METHODS FOR THE ESTIMATION OF ALCOHOLIC AND OTHER CONSTITUENTS IN SYNTHETIC MIXTURES AND ESSENTIAL OILS, PART VII, TERNARY SYSTEM

By

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ABSTRACT

Experimental verification of the formulae based on density of the synthetic mixture and its individual constituents and ester value and oxime number of the mixture before acetylation has been studied. It was observed during the investigation that the percentage of individual components present in a ternary mixture could be determined with sufficient accuracy (within $\pm$ 1 percent) if the constituents are similar in chemical nature and the density of the constituents differ from each other appreciably by not less than 0·017.

In a previous communication Lal and coworkers[1] had derived the following formulae 1 and 2 for the determination of the percentage of two alcohols present in the ternary mixtures. In the present investigation application of the two sets of formulae 1, 2, 3 and 1a, 2a and 3a has been studied in case of two ternary systems—one consisting of phenyl propyl alcohol, benzyl alcohol and beta-phenyl-ethyl acetate and the second consisting of phenyl ethyl alcohol, benzyl alcohol and acetophenone.

Phenyl propyl alcohol %, $a = \dfrac{100\ (h_b - h_m) + c(h_a - h_o)}{h_a - h_b}$ ...(1)

Benzyl alcohol %, $b = \dfrac{100\ (h_a - h_m) + c\ (h_b - h_o)}{h_b - h_a}$ ...(2)

Phenyl ethyl acetate %, $c = \dfrac{100 V_1}{V_o}$ ...(3)

Phenyl ethyl alcohol %, $a = \dfrac{100\ (h_b - h_m) + k\ (h_a - h_k)}{h_a - h_b}$ ...(1a)

Benzyl alcohol %, $b = \dfrac{100\ (h_a - h_m) + k\ (h_b - h_k)}{h_b - h_a}$ ...(2a)

Acetophenone %, $k = \dfrac{p M_k}{20 s}$ ...(3a)

Where a and b are the percentage of alcohol A and B while c and k are the percentage of ester C or ketone K present in the ternary mixture. Further, h_a, h_b, h_o and h_k are the specific volume of component A, B, C and K respectively. Let V_o be the ester value of pure ester C, V_1 the ester value of the mixture, h_m specific volume of the mixture, M_k the molecular weight of ketone K and p the number of cc. of 0·5 N alcoholic potassium hydroxide used for neutralization of the hydrochloric acid liberated from hydroxylamine hydrochloride during oximation[2] of s gm. of the sample.

EXPERIMENTAL

Phenyl propyl alcohol and phenyl ethyl alcohol of 99·0% purity (M/s. Polak and Schwartz, Holland), benzyl alcohol 94·2% purity (M/s. British Drug Houses, London) and phenyl ethyl acetate 98·5% purity and acetophenone 99·5% purity (M/s. Rhodia, France), were fractionated under reduced pressure using Towers fractionating column. Fractions collected and employed in the preparation of mixtures had the characteristics detailed in table I. The following synthetic mixtures of different composition were prepared using purified chemicals and kept in amber coloured bottles for use :—

(i) Phenyl propyl alcohol, benzyl alcohol and phenyl ethyl acetate.

(ii) Phenyl ethyl alcohol, benzyl alcohol and acetophenone.

Determination of Ester Value.

In the determination of saponification value 1·5 to 4·5 gm. of the mixture were refluxed with 25 c.c. of standard alcoholic potassium hydroxide solution of about 0·5N and standard hydrochloric acid of about 0·3N was used for titrating the excess of alkali, so that in the blank experiment about 40 c.c. of the standard hydrochloric acid solution were used. Care was taken that the difference in the volume of acid used in the blank and that in actual experiment was more that 10 c.c. so as to obtain accurate results. The weight of a mixture for saponification value determination was taken according to its ester content.

The acid value of mixture was determined, with the help of a microburette reading upto 0·01 cc. The ester content was calculated with the help of formula 3 and the results are detailed in table II.

Estimation of Acetophenone.

Approximately 0·5N hydroxylamine hydrochloride solution was prepared as advocated by Guenther[2]. Accurately weighed sample of pure acetophenone or mixtures containing acetophenone 1 to 4 gms according to its acetophenone content were taken and 75 c.c. of hydroxylamine hydrochloride were added from a burette to each flask containing the weighed sample. The contents of the flask were kept at room temperature for half an hour and the liberated hydrochloric acid was titrated against 0·3N standard alcoholic caustic potash solution. A blank experiment was also performed side by side. The titration was continued until the greenish shade of the solution matched with the blank. Care was taken that the difference in the volume of alcoholic caustic potash used in the sample and the blank titration should be more than 10 c.c. to obtained accurate results. Percentage of acetophenone in the mixtures was calculated with the help of fomulae (3a) and results are detailed in table IV.

Specific gravity of the components and the synthetic mixtures at 25°C was determined by the method described by Lal *et al*[3] using a double jacketed pyknometer having a thermometer reading upto 0·2°C. Specific gravity was calculated with the help of formula given below using a seven figure logarithmic table.

$$\text{sp. gr. at } t°C = \frac{\text{Weight of the liquid at } t°C}{\text{weight of an equal volume of water at } t°C}$$

The specific gravity found was converted into density[4] with the help of formula 4.

$$d_4^t = d_t^t \cdot d_4^t \text{ (water)} \quad ...(4)$$

TABLE 1

Physico-chemical constants of chemicals used

Particulars	Phenyl ethyl alcohol	Benzyl alcohol	Phenyl propyl alcohol	Phenyl ethyl acetate	Aceto-phenone
1. Specific gravity 25°/25°C	1·01854	1·04428	1·00064	1·03187	1·02674
2. Density 25°C ...	1·015562	1·041225	0·997719	1·028856	1·023735
3. Specific volume 25°C ...	0·984676	0·960407	1·002281	0·971954	0·976816
4. Boiling point °C/mm ...	93°/6	77-78°/4	99°/6	92°/4	68°/5
5. Acid Value ...	0	0	0	0	0
6. Ester Value before acetylation.	0	0	0	341·9	---
7. Ester value after acetylation.	342·6	374·1	314·8	...	---
8. % purity ...	100·2	100·1	100·0	100·1	99·9

TABLE II

Phenyl ethyl acetate, phenyl propyl alcohol and benzyl alcohol system

Mixture No.	1	2	3	4	5
1. % Composition					
(a) Phenyl ethyl acetate	64·84	16·04	22·49	50·77	16·16
(b) Phenyl propyl alcohol	5·09	10·36	38·50	41·07	66·37
(c) Benzyl alcohol	30·07	73·61	38·93	8·16	17·47
2. Sp. gravity at 25/25°C	1·03403	1·03799	1·02454	1·01929	1·01304
3. Density 25°C/4°C	1·031005	1·034952	1·021543	1·01631	1·010082
4. Sp. volume at 25°C/4°C	0·969927	0·966223	0·978917	0·983952	0·990019
5. *Before acetylation.*					
(a) Acid value	0	0	0	0	0
(b) Ester value (Mean)	221·4	55·37	76·86	173·19	56·24
6. *Found %*					
(a) Phenyl ethyl acetate	64·79	16·21	22·49	50·69	16·46
(b) Phenyl propyl alcohol	4·8	9·25	37·91	42·24	66·14
(c) Benzyl alcohol	30·41	74·52	39·59	7·08	17·40
7. *Deviation in.*					
(a) Phenyl ethyl acetate %	−0·05	+0·17	0·0	−0·08	+0·3
(b) Phenyl propyl ,, %	−0·29	−1·11	−0·59	+1·17	−0·23
(c) Benzyl alcohol %	+0·34	+0·91	+0·66	−1·08	−0·07
8. *Total alcohol%*					
(a) Actual	35·16	83·97	77·43	49·23	83·84
(b) Found	35·21	83·77	77·50	49·32	83·54
(c) Deviation	+0·05	−0·2	+0·07	+0·09	−0·3

TABLE III
Phenyl ethyl alcohol, benzyl alcohol and acetophenone system

Mixture No.	1	2	3	4
1. % *Composition*				
(a) Phenyl ethyl alcohol ...	75·52	60·49	39·38	19·34
(b) Benzyl Alcohol ...	15·23	20·55	40·71	71·15
(c) Acetophenone ...	9·25	18·96	19·91	9·51
2. Specific gravity 25/25°C ...	1·02343	1·02586	1·03122	1·03895
3. Density, 25°C/4°C ...	1·0204409	1·02286	1·0228201	1·03497
4. Specific volume, 25°C/4°C	0·979969	0·977652	0·972572	0·9662104
5. *Before acetylation.*				
(a) Acid value ...	0	0	0	0
6. % *Composition (found)*.				
(a) Phenyl ethyl alcohol ...	74·60	58·45	38·91	17·53
(b) Benzyl Alcohol ...	16·51	22·93	43·54	73·05
(c) Acetophenone (Oximation).	8·92	18·58	19·56	9·44
7. *Deviation in :*				
(a) Phenyl ethyl alcohol %	−1·92	−2·04	−0·47	−1·81
(b) Benzyl Alcohol % ..	+1·28	+2·38	+2·83	+1·90
(c) Acetophenone % ---	−0·33	−0·38	−0·35	−0·07
8. *Total alcohol %* ...				
(a) Actual ...	90·75	81·04	80·09	90·49
(b) Found ...	91·11	81·38	80·85	90·58
(c) Deviation ...	+0·36	+0·26	+0·36	+0·09

TABLE IV

Determination of acetophenone

Mixture No.	1	2	3	4
1. Mixture, gms. (i) ...	3·9608	3·7168	3·2702	4·4802
(ii) ...	4·2100	3·8252	4·0260	4·5082
2. 0·24612N Alcoholic KOH c.c.				
(i) ...	11·95	23·3	21·60	14·3
(ii) ...	12·7	24·1	26·6	14·4
3. % Acetophenone				
(i) ...	8·92	18·54	19·53	9·44
(ii) ...	8·92	18·63	19·59	9·45
Mean ...	8·92	18·58	19·56	9·44

DISCUSSION AND CONCLUSION

The composition of two synthetic ternary mixtures was calculated from the specific volumes of the mixture and that of the pure components with the help of the formulae 1, 2 and 1a and 2a respectively. The results are detailed in tables II and III. Phenyl propyl alcohol and benzyl alcohol contents were found to agree with the actual values within an error of one percent, the minimum difference in the density of two components, namely, benzyl alcohol and phenyl ethyl acetate being 0·0175 gm. per c.c., (diff. in sp. volume 0·01154 c.c., per gm.). In the case of the ternary system consisting of benzyl alcohol, phenyl ethyl alcohol and acetophenone. The difference in the density of two key components (phenyl ethyl alcohol and acetophenone) was as low as 0·008 gms. per c.c. with the result that the percentage of individual components were found to agree with the actual values within an arror of 2·8 percent.

The formulae given in the introductory part based on density give correct results and in the hands of essential oil chemists it is a new procedure for determining the composition of the synthetic mixtures and fractions of natural essential oils containing two different alcohols and one ester or one ketone. The method is handy and the results can be obtained within a shorter time as compared to acetylation and formylation methods. The formulae become more handy when specific volume is used instead of density.

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STUDY OF THE REACTION BETWEEN MANGANESE (II) AND SULPHOSALICYLIC ACID

By

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ABSTRACT

A 1:1 complex between manganese (II) and sulphosalicylic acid has been reported. The monovariation method has been employed to get the indication which has been confirmed by the Job's method of continuous variation. Both the pH and conductometric measurements have been done in the former whereas only the conductance measurements have been employed in the latter case. A probable mechanism has been suggested on the basis of the pH titrations and the value of the dissociation constant, 1.25×10^{-3} at 27° C, which has been obtained by the Job's method taking non-equimolecular solutions.

Sulphosalicylic acid is known to form complexes with a large number of metal ions. Turner and Anderson[1] have reported two complexes with copper having compositions of 1:1 and 1:2 in the pH range of 3-5.5 and 8.5, respectively. The spectrophotometric method has been applied to investigate the Fe(III) – sulphosalicylate system by Foley and Anderson[2] and a 1:1 complex has been concluded which has been confirmed with the help of the conductometric method by Singh and Prakash[3]. Nanda and Aditya[4] have reported a 1:1 complex with aluminium. Chibnall and Cannan[5] using ion exchange method have given evidence of a 1:1 chelate with Ra(II). Bank and Singh[6] have found two complexes with beryllium at pH 5.2 and 8.0 respectively of the compositions 1:1 and 1:2.

It has been seen that there has been so far no attempt to study the mechanism of the system Mn(II)-sulphosalicylic acid and this has been studied by the present authors.

EXPERIMENTAL

Manganous chloride (B. D. H. Analar) was taken and analysed by the usual method. The analysis corresponds to $MnCl_2.4H_2O$. This was dissolved in conductivity water and standard solutions were prepared by direct weighing. Sulphosalicylic acid (Reidel, recrystallized sample) was taken and its solution was also prepared in conductivity water.

Electrical conductance measurements were carried out by a Doran's conductivity bridge with a WTW Oscillator using a dip type cell. Beckmann pH Meter was employed for the pH measurements. The solutions were maintained at a temperature of $27 \pm 0.1^\circ$ C in a thermostat.

Stoichiometry. The monovariation method was first employed in order to get an indication regarding the nature of complex formation. It has been concluded

from both the conductance and pH measurements that there is a 1:1 complex between them (Fig. I).
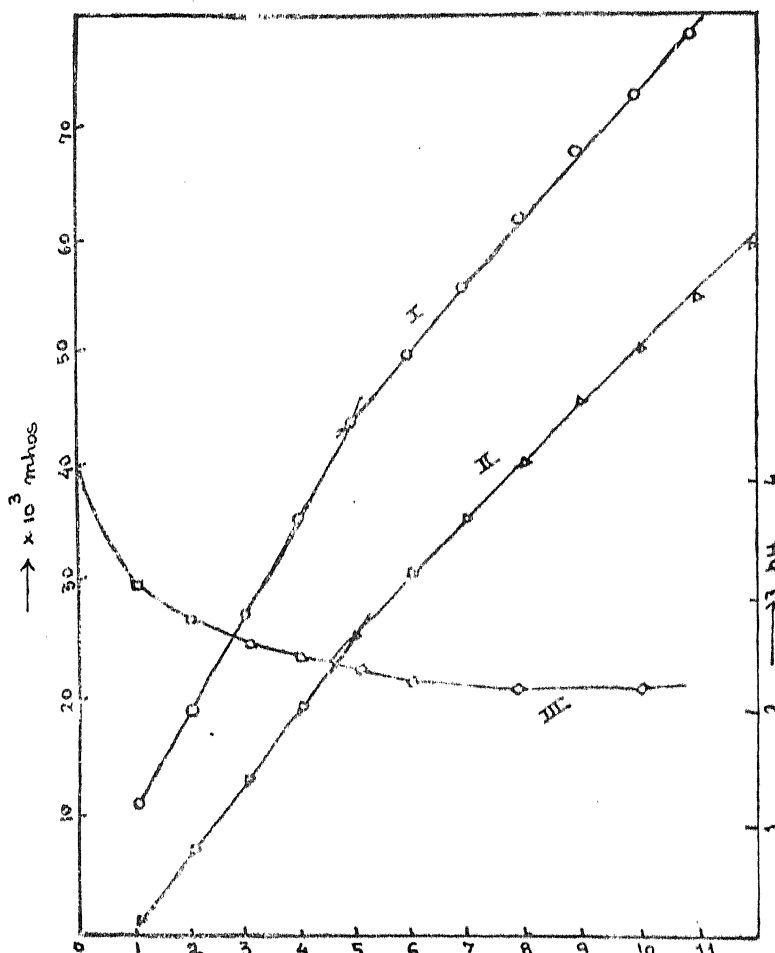

Fig. 1.—ml. of 5-sulphosalicylic acid added→.

The composition of the complex was confirmed by the Job's continuous variation method[7] using electrical conductance data. Different sets of equimolecular mixtures of manganous chloride and sulphosalicylic acid were prepred. The various compositions used were M/30, M/40 and M/50 and their conductance was measured. Similar blank experiments were performed with manganous chloride and sulphosalicylic acid separately. The divergence from the additivity rule was plotted against the composition (Fig. II) and the maxima in the curves show the formation of a 1:1 complex between manganous chloride and sulphosalicylic acid.

DISSOCIATION CONSTANT

The value of the dissociation constant was calculated by the Job's method[7]. For this purpose non-equimolecular solutions were prepared. The enlarged

equation of Job is reduced to the following as $m=1$ and $n=1$ (being a 1:1 complex)

$$K = \frac{c\ |(p+1)\ x-1]}{(p-1)\ (1-2x)^2}$$

where K = dissociation constant, c = the concentration of the metal solution, p = the ratio of the concentrations of the ligand and the metal ion solution and x = the maximum amount of the ligand employed. The average value of the dissociation constant obtained is 1.25×10^{-3} at 27°C (Fig. III).
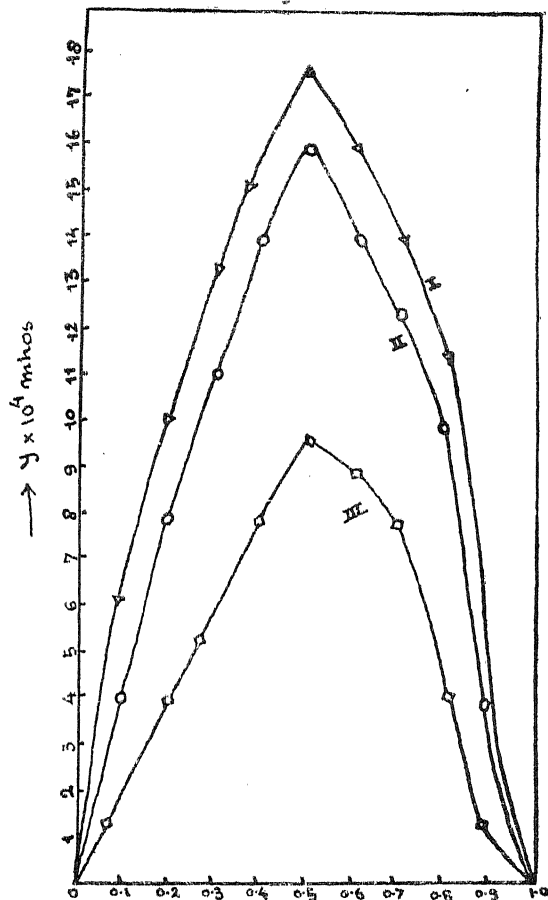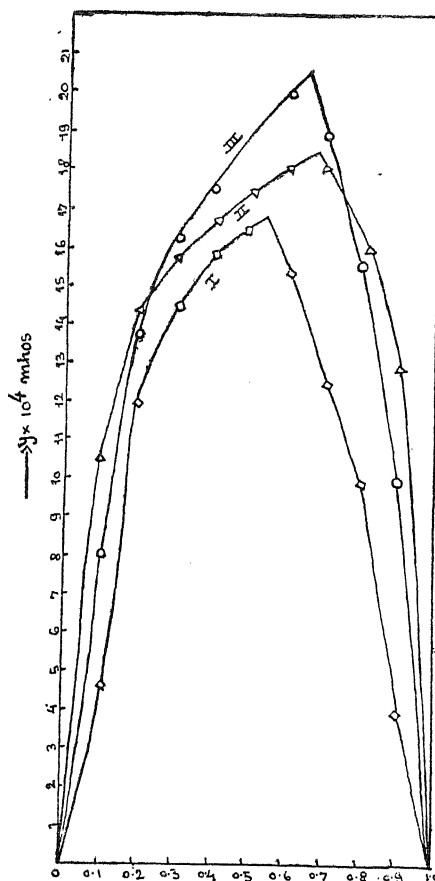

Fig. 2. $\dfrac{[L]}{[M]+[L]}$ →

Fig. 3. $\dfrac{[L]}{[M]+[L]}$ →

DISCUSSION

It is noted from the monovariation curves (Fig. I) that a sharp break occurs at the metal-ligand ratio of 1:1, indicating this composition for the complex.

Curves I & II of fig IV represent respectively the titration of M/20 H_3SSA (sulphosalicylic acid) and of a 1:1 mixture of M/40 $MnCl_2$ and M/40 H_3SSA with

NaOH. The titrations were followed by observing the changes in conductance (Curves I & III) and pH (curves II & IV) of the solutions. Curve I for H_3SSA shows two breaks, first when one equivalent of alkali is added and the second when nearly two equivalents of alkali are added. It appears, therefore, that under the experimental conditions the phenolic proton of H_3SSA is not titrated. Curve III indicates only one inflection when two equivalents of alkali are added. Curve III also shows two breaks; first when one equivalent of alkali is added and the second when three equivalents of alkali are added. The first break corresponds to the replacement of the sulphonic proton and the second to the formation of $MnSSA^-$. Curve IV shows two breaks which justify the reactions postulated for Curve III.
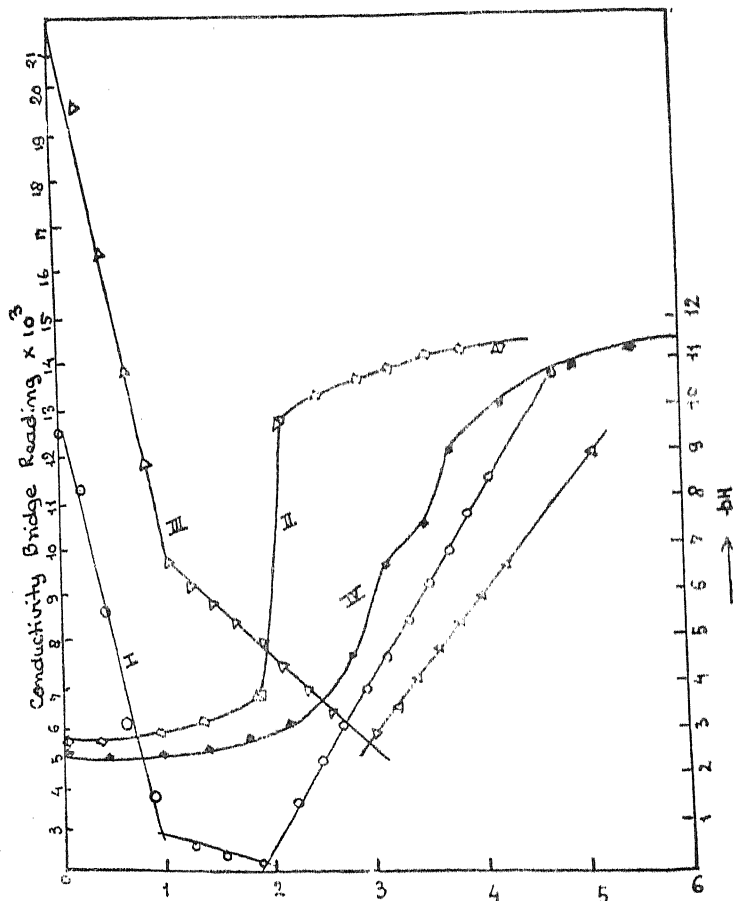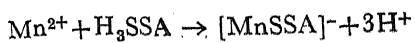

Fig. 4—Equivalents of NaOH per equivalent of acid.

On the basis of the above justification we propose the following mechanism for the reaction.

$$Mn^{2+} + H_3SSA \rightarrow [MnSSA]^- + 3H^+$$

Further work with the other derivatives of salicylic acid using various physico-chemical methods is in progress. The authors express their grateful thanks to Prof. A. K. Bhattacharya for the keen interest that he has evinced in the present work.

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COMPOUNDS OF LEAD IODIDE WITH ALKALI AND ALKALINE EARTH METAL IODIDES IN ACETONE

By

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ABSTRACT

Compounds of lead iodide with alkali and alkaline earth metal iodides have been prepared in acetone, their general properties studied and structures discussed.

INTRODUCTION

A number of compounds of PbI_2 with other metal iodides have been prepared in water medium and all the compounds formed contained water molecule. No work on the formation of these compounds in non-aqueous media is reported in the literature.

Brooks[1] prepared the compounds of PbI_2 with KI, Wells and Johnston[2] with NH_4I, Ditte[3] with NH_4I, NaI and KI, Mosnier[4,5] with NH_4I, LiI, NaI, CaI_2 SrI_2, PI_3 AsI_3, SbI_3, BiI_3, Al_2I_6, SnI_2 and BeI_2 and Bogorodoski[6] with LiI. From the studies of the solubility curves of PbI_2 and alkali iodides in H I Lanford and Kiehl[7] showed that a compound of the type of K_2PbI_4 existed in solution.

The present investigation was, therefore, undertaken with a view to studying the formation of compounds of PbI_2 with alkali and alkaline earth metal iodides.

EXPERIMENTAL

All the chemicals used were of Merck's or B. D. H. extra pure quality. Acetone was dehydrated and redistilled.

A saturated solution of alkali or alkaline earth metal iodides in acetone was taken in a glass stoppered conical flask and small quantities of PbI_2 added to it with constant shaking until no more of it was soluble. A slight excess of PbI_2 was then added and the mixture left for 72 hours with frequent shaking. It was filtered and the filtrate evaporated to dryness. The compound was finally dried over $CaCl_2$ in Vacuum desiccator and analysed.

Nitrogen was estimated by Kjeldahl's and iodine by Piria and Schiff's method. Pb, Sr and Ba were estimated as sulphates, Mg as pyrophosphate, potassium as perchlorate. Ca was precipitated as oxalate dissolved in H_2SO_4 and titrated against standard $KMnO_4$ solution. Sodium and lithium were found by difference.

GENERAL PROPERTIES AND DISCUSSION OF THE RESULTS

Almost all the compounds are coloured and fairly stable in dry atmosphere. These are hygroscopic and decompose when left in moist air for a long time or treated with water. These compounds contain no acetone molecule. They are insoluble in alcohol and ether and other non-polar solvents but soluble in acetone.

TABLE

Compounds of lead iodide with alkali and alkaline earth metal iodides

No.	Other iodides	Colur of the compounds	% Lead Found	Calc.	% Iodine Found	Calc.	% Other Metals Found	Calc.	Probable formulae
1.	LiI	Brownish yellow	28·38	28·42	69·61	69·66	1·80	1·90	$Li_2 [PbI_4]$
2.	NaI	Yellow	27·10	27·22	66·76	66·74	5·98	6·04	$Na_2 [PbI_4]$
3.	KI	White	26·19	26·12	64·02	64·04	9·82	9·85	$K_2 [PbI_4]$
4.	NH_4I	Yellow	27·50	27·58	67·66	67·62	N = 3·48	N = 3·53	$(NH_4)_2[PbI_4]$
5.	MgI_2	Reddish yellow	28·06	28·02	68·63	68·69	3·20	3·24	$Mg [PbI_4]$
6.	CaI_2	Reddish yellow	27·40	27·44	67·30	67·26	5·32	5·30	$Ca [PbI_4]$
7.	SrI_2	Yellow	25·84	25·82	63·20	63·28	10·90	10·91	$Sr [PbI_4]$
8.	BaI_2	Yellow	24·28	24·30	59·52	59·58	16·15	16·11	$Ba [PbI_4]$

No compound could be isolated with ZnI_2, CdI_2 or HgI_2.

Lead iodide is insoluble in acetone but its solubility increases in the presence of these iodides, which indicates the formation of complex compound. It seems probable that lead passes into the tetravalent state with the formation of plumbo-iodide ion, $[Pb\ I_4]^{--}$, which gives the compounds having the general formulae $M_2'\ [Pb\ I_4]$ and $M''[Pb\ I_4]$ (M' = alkali and M'' = alkaline earth metal). The E. A. N. does not assume the inert gas configuration and the compounds are unstable. In the case of zinc, cadmium and mercury, which are less electropositive than alkali and alkaline earth metals, similar compounds are not formed.

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CHEMICAL INVESTIGATION OF EQUISETUM DEBILE ROXB

By

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Equisetum debile—(Vern. nari) is a small herbaceous plant which grows all over India along shady streams. It is extensively used in the indigenous system of medicine as colling agent and in the treatment of gonorrhagea. The plant has not been investigated before and as a result of the present investigation nicotine in 0·06 per cent field has been isolated from this.

The dry area stems of the plant *Equisetum debile* were coarsely powdered and exhausted with alcohol, solvent was removed under reduced pressure. . The semi-solid extract left was treated with dilute hydrochloric acid a number of times till free from alkaloids. The acidic extract was treated with animal charcoal and filtered. The filterate was given two washings with ether to remove non-alkaloidal impurities, it was basified with ammonia and extracted with ether. The extractions were dried over anhydrous sodium sulphate and solvent distilled off. The residue was obtained as a dark coloured oily liquid which smelt strongly of nictine. It gave dipicrate m. p. 224°-225° and tartrate, m. p. 88-89°C. The melting points were not depressed when taken in admixture with authentic specimens of nictine salts. The alkaloid and an authentic specimen of nicotine also showed the same R_F value (0·57) in butanol-acitic acid-water (4:1:5) system.

STUDIES ON THE VELOCITY OF FLOW OF LIQUIDS THROUGH ADSORBENT COLUMNS

PART IX. THE CORRELATION OF $\dfrac{Vh}{t} \cdot \eta/d = K$ WITH POISEUILLE'S EQUATION

By

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ABSTRACT

The equation $\dfrac{Vh}{t} \cdot \dfrac{\eta}{d} = K$, for the velocity of flow of liquids through adsorbent columns, has been correlated with the Poiseuille's equation, $V = K \cdot \dfrac{\pi R^4 . Pt}{8\eta . h}$, and it has been shown that it is a modified form of the latter.

In the previous communications[1-5], the authors have developed an empirical equation $\dfrac{Vh}{t} \cdot \dfrac{\eta}{d} = K$ for the flow of organic liquids through adsorbent columns, where V is the volume of the liquid flowed through, h, the height of the adsorbent column in time t, η, the viscosity of the liquid and d its density. The equation gave a very significant K for different homologous series of organic compound. Taking into consideration the important role of the structural characteristics of liquids and adsorbents in determining the velocity of flow of liquids through adsorbent columns, and also by comparing the demensions of K in the equation $\dfrac{Vh}{t} \cdot \dfrac{\eta}{d} = K$, with those of K in the Darcy's equation $V = K. \dfrac{d^2}{\eta} \cdot \dfrac{dp}{dx}$, it was shown[4,6] that the equation given by the authors is a particular form of the Darcy's law. In the present communication, the authors have correlated their equation with Poiseuille's equation on the flow of liquids through capillary tubes.

The Poiseuille's equation[7] may be written as :

$$V = K \frac{\pi R^4 Pt}{8 h . \eta} \quad \ldots\ldots\ldots\ldots (I)$$

where, V, is the volume of a liquid of viscosity η flowed in time t through a capillary tube of radius R and length h, under a constant pressure P which is the difference of pressure at the two ends of the column of the flowing liquid.

While comparing the flow of a liquid through an adsorbent column with that of a liquid through a glass capillary, the height, h, of the adsorbent column may be taken as equal to the length of the capillary in Poiseuille's equation. If the flow of the liquid is vertically downwards as in the measurements of viscosity

by Ostwald's viscometer, and the pressure, both at the top of the liquid column and in the space in which the liquid flows, is the atmospheric pressure, then P becomes the hydrostatic pressure of the liquid column under which a liquid flows through an adsorbent column, and this may be put as ldg, where l is the height of the whole liquid column which is equal to the height of the adsorbent column plus the height of the liquid above it and d is the density of the liquid. R' may be considered as a measure of the diameter of the capillaries of an adsorbent column through which a liquid flows. R' will depend upon the structural characteristics of the flowing liquid and the adsorption affinity of an adsorbent. Substituting the values of P and R in Poiseuille's equation, we get :

$$V = K. \frac{\pi R'^4. \; ldg.t}{8 \eta. h} \; .$$

$$\text{or} \frac{Vh}{t} . \frac{\eta}{d} = K. \frac{\pi R'^4 \; lg}{8} \; .$$

$$= K_1 \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; (2)$$

Thus the equation (2) is the same as arrived at by the authors[4] for the flow of a liquids through an adsorbent column.

According to Poiseuille, the equation (I) should hold good for all liquids and the coefficient of viscosity is determined by measuring the flow through the glass capillaries, assuming that the properties of the glass surface remain constant. So, the character of the surface of the capillary is also involved in the determination of the viscosity by Poiseuille's equation, though it is not expressly mentioned. But the case is different for the capillaries of a packed column of adsorbents, the passages of which will be governed by the solid-liquid interfacial forces which depend upon the structure of the liquids and also the surface properties of the adsorbent particles. The surface capillaries and interstitial forces are characteristic of the structure and adsorption affinity at the liquid-solid interface; therefore, the rate of flow of liquids through these capillaries will depend not only upon the size and shape of the pores but also on the chemical structure of the solid and the liquid. The Poiseuille's equation, however, does not refer to the influence of surface active forces and the chemical structure of the liquids when they flow through the capillary of a viscometer.

Thus the equation $\frac{Vh}{t} . \frac{\eta}{d} = K$ for the flow of liquids through adsorbent columns may be considered as a modified form of Poiseuille's equation, as it takes into account the structural characteristics of liquid molecules as well as the surface active properties of the adsorbents.

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STUDIES ON THE VELOCITY OF FLOW OF LIQUIDS THROUGH ABSORBENT COLUMNS

PART X. GRAPHICAL RELATION BETWEEN vh/t AND d/η FOR ORGANIC LIQUIDS BELONGING TO DIFFERENT HOMOLOGOUS SERIES

By

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ABSTRACT

The relation between the velocity of flow of organic liquids of different homologous series through unit height of various adsorbents (v/t), and the ratio of density to viscosity (d/η) has been studied graphically. It has been observed that (vh/t) is directly proportional to (d/η), as the curves between (vh/t) and (d/η) are almost linear.

In previous communications[1-3] the authors have derived an empirical equation vh/t. $\eta/\alpha = K$, for the flow of organic liquids through different adsorbent columns, where v is the volume of a liquid flown through, h, the height of the adsorbent column in time t; η and d are the viscosity and density of the liquid respectively. While deriving the above equation, it was assumed[3] that vh/t is proportional to d/η. In the present communication, the authors have interpreted graphically the data for vh/t and d/η for the flow of alcohols, esters, ketones and aromatic hydrocarbons through absorbent columns of calcium carbonate, alumina, calcium hydroxide, silicic acid, Fuller's earth, Kieselguhr and sugar charcoal.

EXPERIMENTAL

The details of the experimental technique for filling the adsorbents in the chromatographic tube and for measuring the rate of flow of liquids through adsorbent columns under a constant suction pressure have been described earlier[1]. The heights of the absorbent columns were maintained between 2·525 cms. and 3·948 cms. in the case of calcium corbonate and alumina where as these were kept at 4·50 cms. for the remaining adsorbents. The data for vh/t and d/η have been given in Table 1 and their graphical analysis is represented by figs. 1 to 7.

$\frac{Vh}{t}$ vs d/η. Adsorbent — Alumna

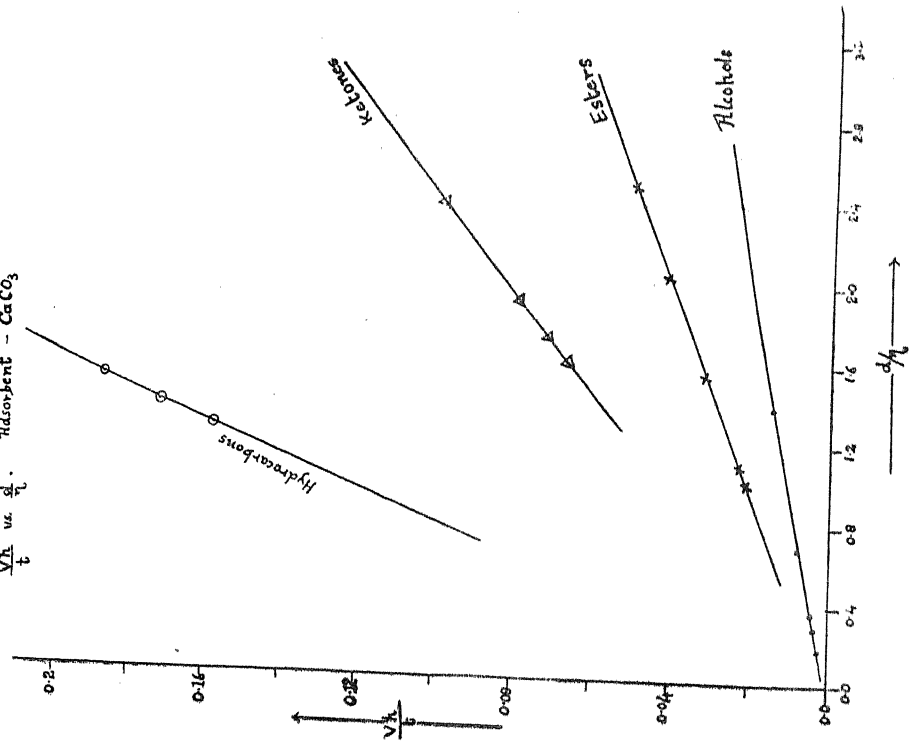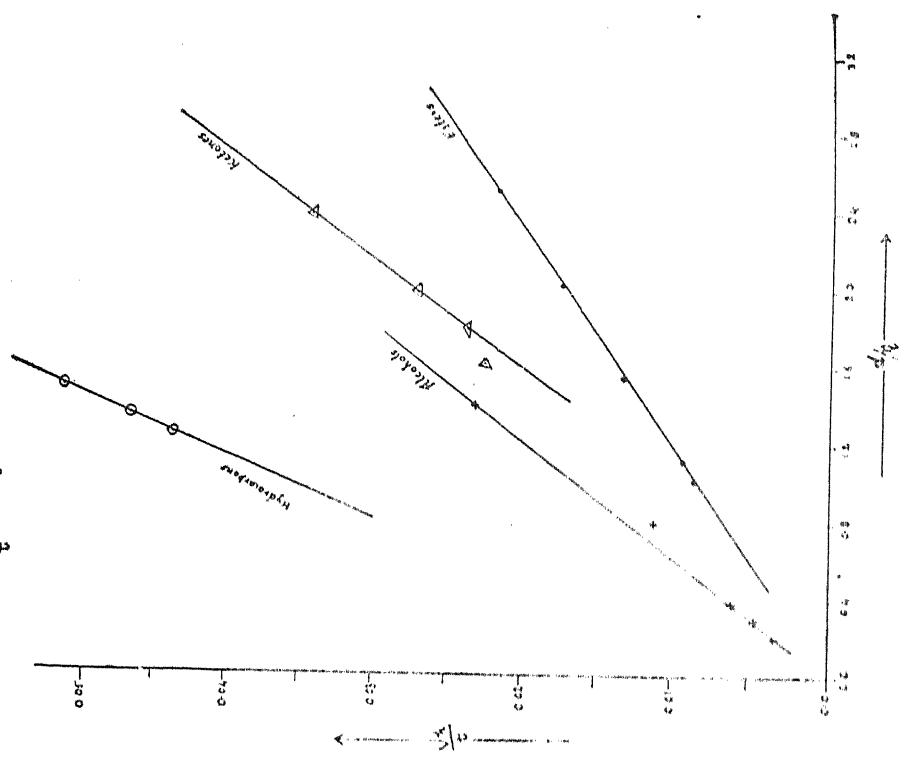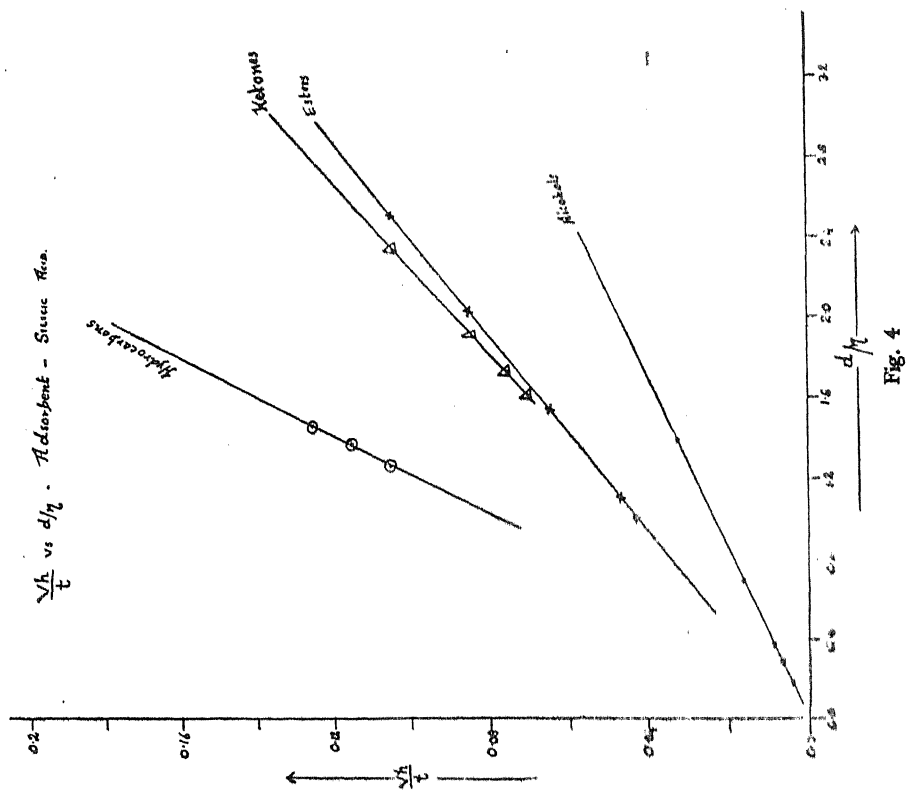Fig. 2

$\frac{Vh}{t}$ vs $\frac{d}{\eta}$. Adsorbent – CaCO₃

Fig. 1

TABLE 1

Height of mercury in the manometer = 34·5 cms.

Temperature = 21·5 ± 1°c.

Liquids	d/η (η = viscosity) × 100	Velocity of flow through unit height of the columns (vh/t)						
		Calcium carbonate	Alumina	Calcium hydroxide	Silicic acid	Fuller's earth	Kieselguhr	Sugar charcoal
1. Methyl alcohol	1·3850	0·0197	0·0228	0·1891	0·0325	0·0215	0·0390	0·1047
2. Ethyl alcohol	0·6885	0·0080	0·0114	0·0942	0·0162	0·0107	0·0194	0·0521
3. n-Propyl alcohol	0·3735	0·0043	0·0062	0·0512	0·0087	0·0058	0·0105	0·0282
4. n-Butyl alcohol	0·2923	0·0034	0·0048	0·0400	0·0069	0·0046	0·0082	0·0222
5. n-amyl alcohol	0·1858	0·0022	0·0031	0·0255	0·0044	0·0029	0·0052	0·0141
6. Methyl acetate	2·4920	0·0493	0·0215	0·3050	0·1050	0·1100	0·1500	0·2196
7. Ethyl acetate	2·0320	0·0415	0·0175	0·2500	0·0857	0·0898	0·1223	0·1787
8. n-Propyl acetate	1·5410	0·0319	0·0133	0·1890	0·0651	0·0679	0·0926	0·1358
9. n-Butyl acetate	1·1110	0·0227	0·0096	0·1363	0·0469	0·0490	0·0669	0·0978
10. n-amyl acetate	1·0300	0·0213	0·0089	0·1270	0·0434	0·0455	0·0621	0·0907
11. Acetone	2·3910	0·0979	0·0341	0·3880	0·1047	0·0714	0·1320	0·3637
12. Methyl ethyl Ketone	1·9170	0·0785	0·0272	0·3125	0·0840	0·0573	0·1056	0·2903
13. Diethyl Ketone	1·7290	0·0708	0·0246	0·2808	0·0757	0·0515	0·0954	0·2628
14. Me. n-Pr. Ketone	1·6000	0·0655	0·0227	0·2598	0·0701	0·0477	0·0883	0·2432
15. Benzene	1·3680	0·1712	0·0467	0·2312	0·1150	0·0841	0·1820	0·1800
16. Toluene	1·4980	0·1861	0·0514	0·2518	0·1260	0·0920	0·1987	0·1951
17. Xylene	1·2520	0·1572	0·0431	0·2113	0·1052	0·0769	0·1664	0·1641

$\dfrac{\sqrt{h}}{t}$ vs d/η . Adsorbent - Silica Gel.

Ketones

Esters

Hydrocarbons

Alcohols

$\dfrac{\sqrt{h}}{t}$

d/η

0·2   0·16   0·12   0·08   0·04   0

0·8   1·0   1·2   1·6   2·0   2·4   2·8   3·2

Fig. 4

$\dfrac{\sqrt{h}}{t}$ vs d/η . Adsorbent - $Ca(OH)_2$

Esters

Ketones

Hydrocarbons

Alcohol

$\dfrac{\sqrt{h}}{t}$

d/η

0·40   0·32   0·24   0·16   0·08

1·0   2·0   3·0

Fig. 3

Fig. 5

$\frac{\sqrt{h}}{t}$ vs d/η. Adsorbent - Fuller's Earth

Ketones

Esters

Hydrocarbons

Alcohols

$\frac{\sqrt{h}}{t}$

d/η

Fig. 6

$\frac{\sqrt{h}}{t}$ vs d/η. Adsorbents - Kieselguhr

Esters

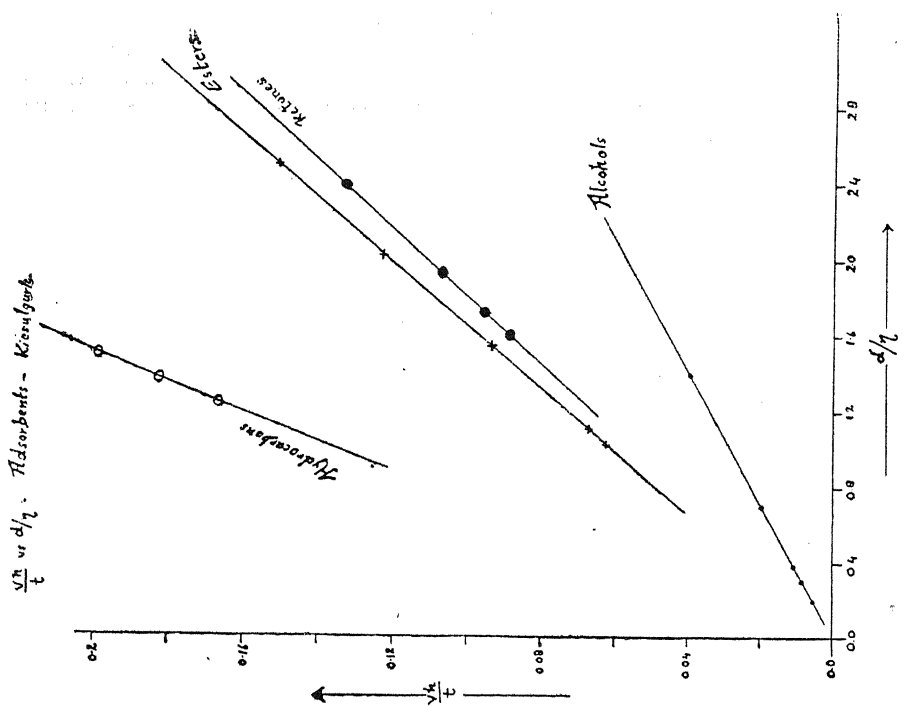Ketones

Hydrocarbons

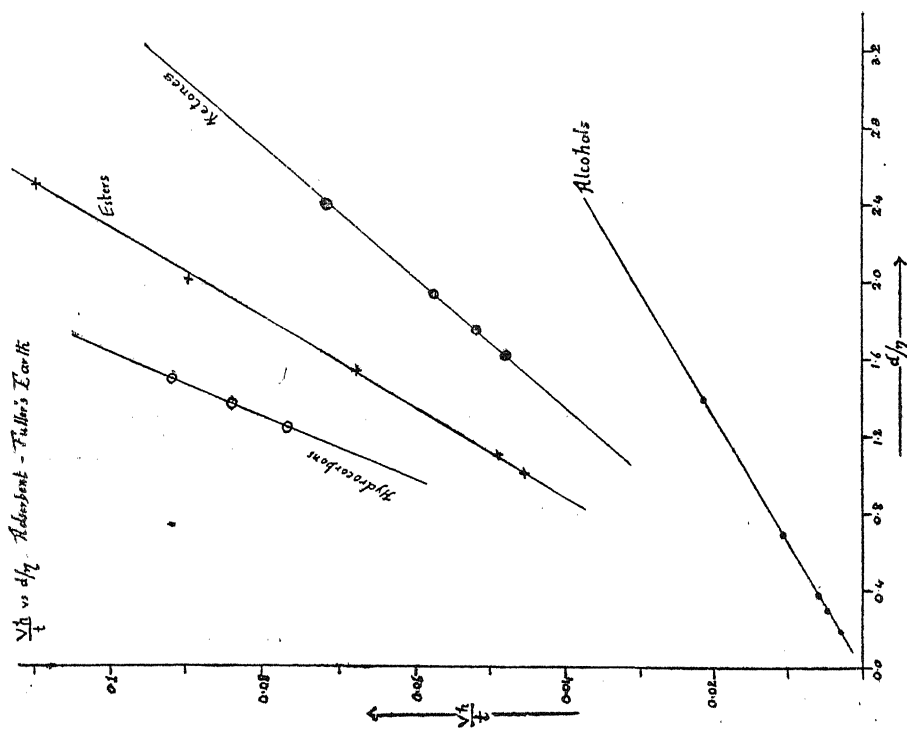Alcohols

$\frac{\sqrt{h}}{t}$

d/η
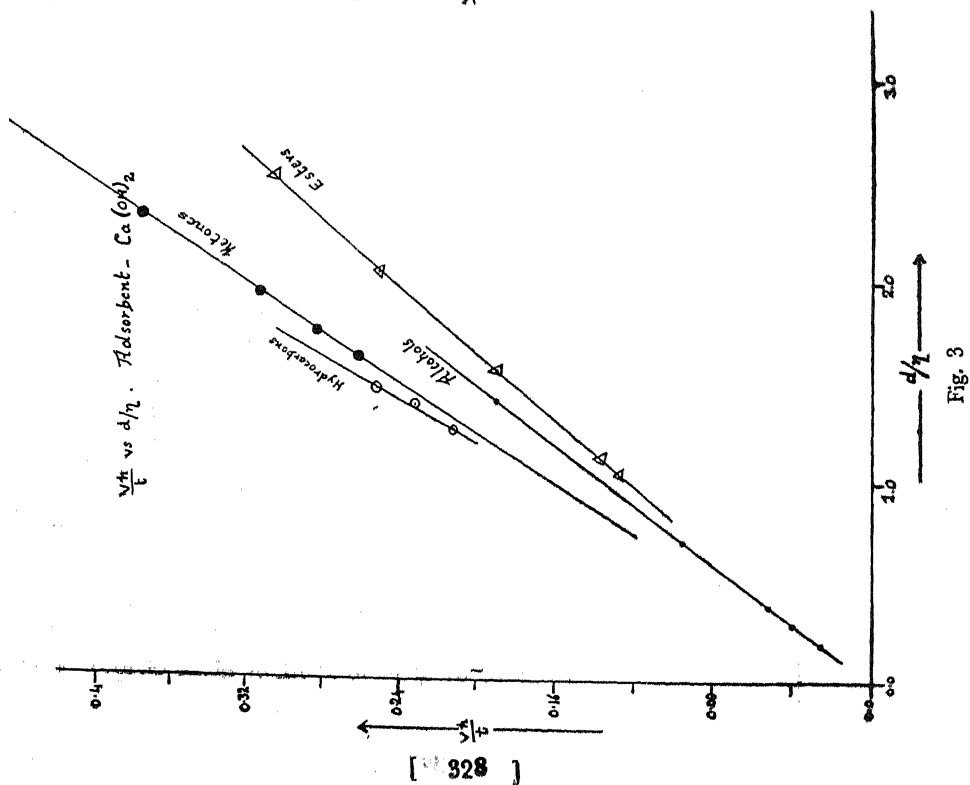
CONCLUSION

It is interesting to observe that the figs. from 1 to 7, showing the relationship between vh/t and d/η for different members of a homologous series, are almost
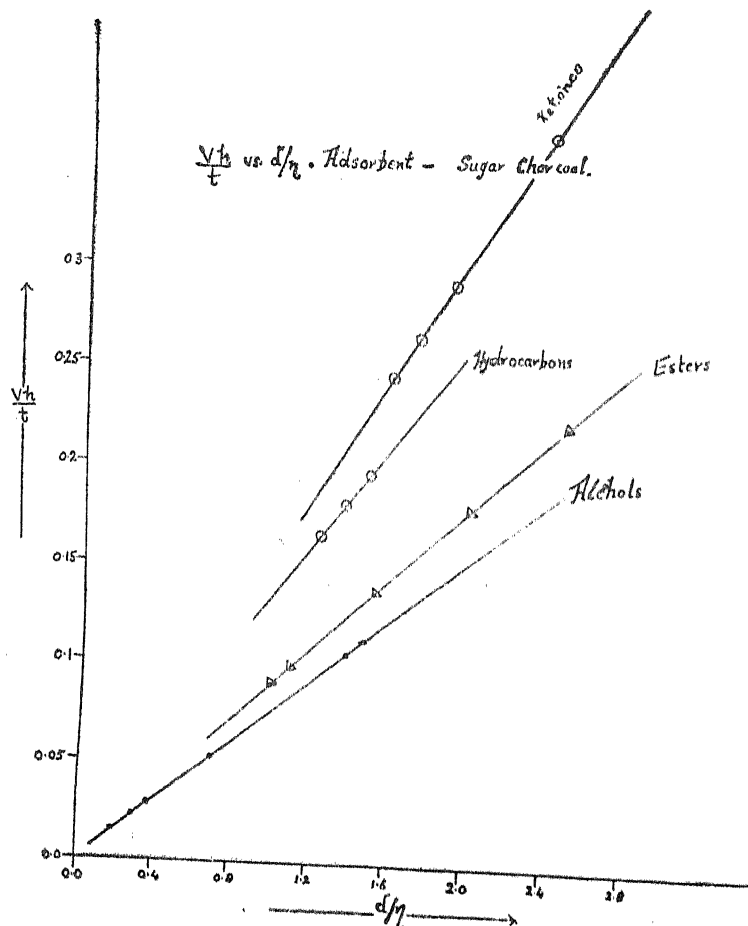
Fig. 7

linear within the limits of the experimental error. The authors' earlier assumption in considering vh/t as proportional to d/η, in deriving the equation vh/t, $\eta/d = K$, is thus experimentally established.

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REDUCTION OF PERMANGANATE AND MANGANESE DIOXIDE BY CITRIC ACID

By

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[Received on 29th October, 1959]

ABSTRACT

Kinetics of the reduction of permanganate by citric acid have been followed iodometrically. The -d(oxidant)/dt curves have one point of inflexion. Mixtures of citric acid and potassium citrate have been employed and the curves have four inflexion points. Hydrogen, manganous and vanadium ions catalyse the reaction. Reduction of MnO_2 has also been studied as it forms an intermediate reduction product of permanganate. MnO_2 on reduction gives Mn(III) which forms yellow or orange complex with citrate. The reduction of this complex is first order in Mn(III) and independent of the concentration of citrate. Within the pH range from 2 to 6, there is an optimum pH in the neighbourhood of 3·5, for which the reaction is fastest. Manganous sulphate catalyses when citric acid is used and suppresses the rate when mixtures are employed.

Reduction of permanganate by citric acid has been studied by Dhar and coworkers[1,2], Cabrera and Rio[3], and Bhale and coworkers[4]. All of them report the reaction to be autocatalytic. Cabrera and Rio[3], found that the rate of reaction decreases with the increase in the concentration of acid, that mineral acids delay the induction period and that Mn(II) diminishes the velocity. Bhale and coworkers[4] reported the reaction to be very fast in presence of Mn(II) and that the rate increases by the addition of sulphuric acid. In view of these contradictory results we have reinvestigated the kinetics of this reaction. The behaviour of Mn(II) largely depends on pH of the system and such contradiction may be real especially when experiments are not performed under similar conditions. We have studied this reaction by employing the mixtures of citric acid and potassium citrate so that small variations in pH could be effected, keeping the hydrogen ion concentration low at the same time.

Reaction of MnO_2 with citric acid was also studied because MnO_2 is the intermediate product in the reduction of permanganate. It is well known that the reduction of permanganate takes place in several steps, each of them involving one electron transfer. MnO_2 on reduction gives Mn(III) which is known to be stable in the form of complexes in absence of sufficient acid. Hence useful information has been obtained as regards the gradual reduction of permanganate from Mn(VII) to Mn(II) by studying the reduction of MnO_2 and its subsequent product Mn(III) by citrate.

EXPERIMENTAL

All the chemicals used were either of B. D. H., A. R., or E. Merck quality. Stock solution of permanganate was prepared in the boiled and cooled distilled water and standardised by sodium arsenite. Citric acid solution was always freshly prepared as it gives a slight turbidity on keeping it for 3 or 4 days. All other solutions were prepared in the usual way.

The reaction was studied in a thermostat at 24°C. 5 ml. portions of the reaction mixture were taken out from the reaction vessel at suitable intervals of time and added to acidified 7% KI solution. The liberated iodine was estimated by 0·005N sodium thiosulphate.

Reduction of Permanganate by Citrate

KMnO$_4$: 0.01 N

Citric Acid   pH

×	0.02 M	2.60
△	0.05 M	2.45
○	0.08 M	2.35

Effect of change of the conen. of the acid

Fig. 1

KMnO$_4$: 0.005 N

Citric Acid   pH

×	0.005 M	3.30
△	0.01 M	2.80
•	0.02 M	2.60
○	0.06 M	2.40

Effect of change of the conen. of the acid

Fig. 2

Time in minutes

Effect of change of pH

KMnO$_4$: 0.01 N

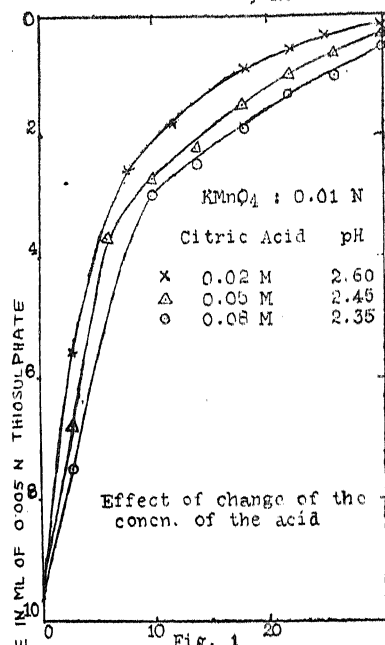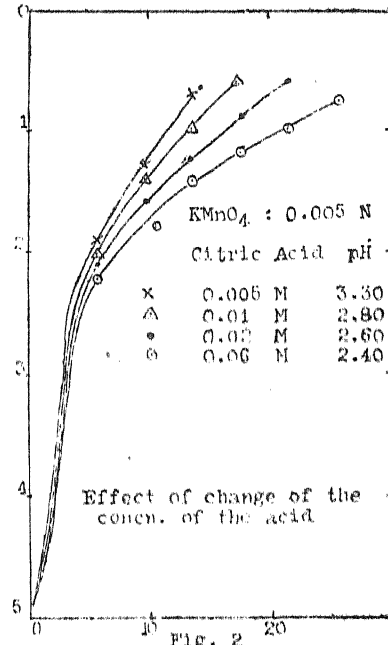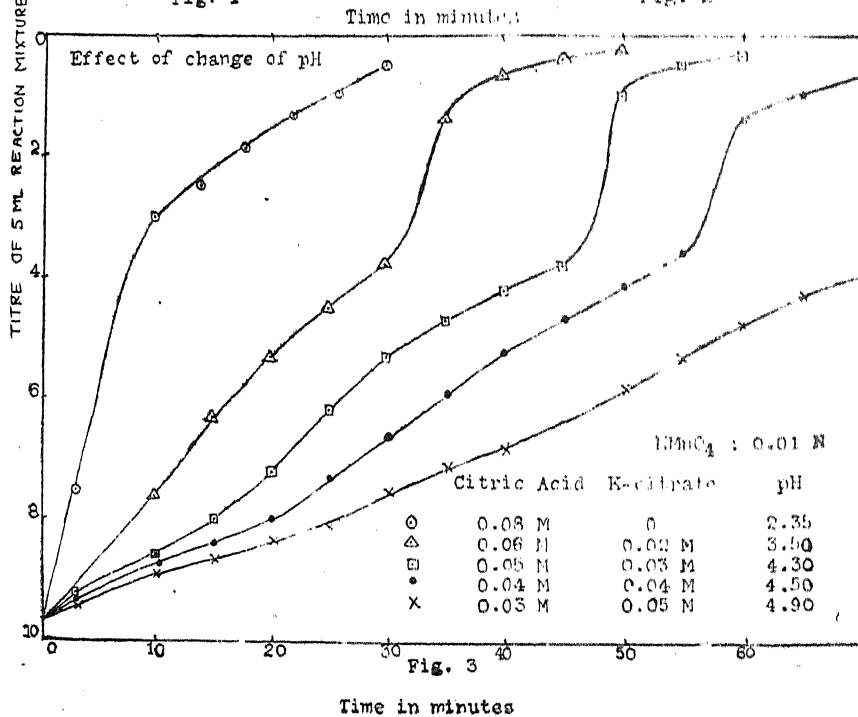|	Citric Acid	K-citrate	pH
○	0.08 M	0	2.35
△	0.06 M	0.02 M	3.50
▫	0.05 M	0.03 M	4.30
•	0.04 M	0.04 M	4.50
×	0.03 M	0.05 M	4.90

Fig. 3

Time in minutes

A suspension of manganese dioxide was prepared by mixing potassium permanganate and manganous sulphate in equivalent amounts together with a little of potassium sulphate and kept for about 24 hours. A black suspension was obtained which was washed free of sulphate ions, made up to a certain volume by means of distilled water and standardised iodometrically. The kinetics were studied as with permanganate. Due care was taken to shake the vessel thoroughly before removing the suspension from the stock solution or from the reaction mixture. The reaction vessel was shaken by means of an electric shaker in order to check the particles of manganese dioxide from settling to the bottom. The mixture became clear and homogeneous in 10 to 15 minutes.
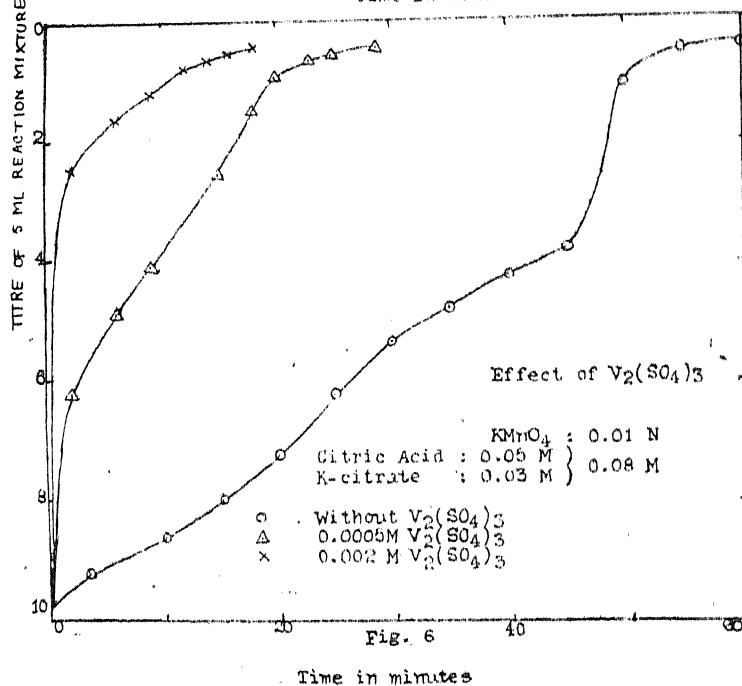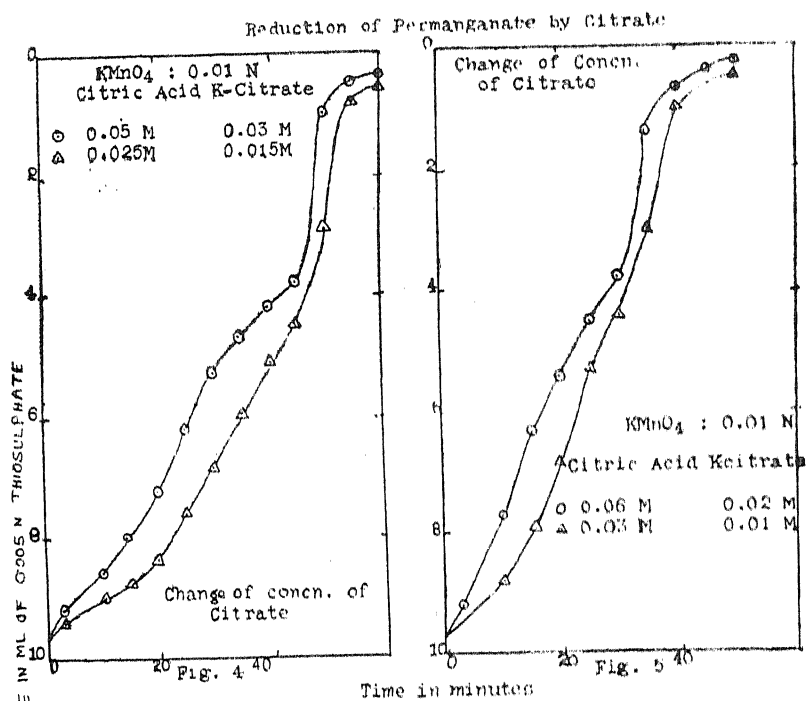
RESULTS AND DISCUSSION

The results with permanganate and citric acid are shown in figs. 1 and 2. The curves for $-d(oxidant)/dt$ consist of two portions, one representing a fast series of reactions and the other gives a slow reaction. From the analogy of the reduction of permanganate by other carboxylic acids[5-9], it may be concluded that the later portion of the curve is the reduction of Mn(III) complexes. In almost every reaction the appearance of yellow or orange colour occurred at the beginning of the second part of this curve. Further, it may be seen that the rate of reaction increases with the decrease in the concentration of citric acid, especially towards the end. The same behaviour is found in the reduction of MnO_2 (fig. 9). This apparent abnormal behaviour is explained later on.
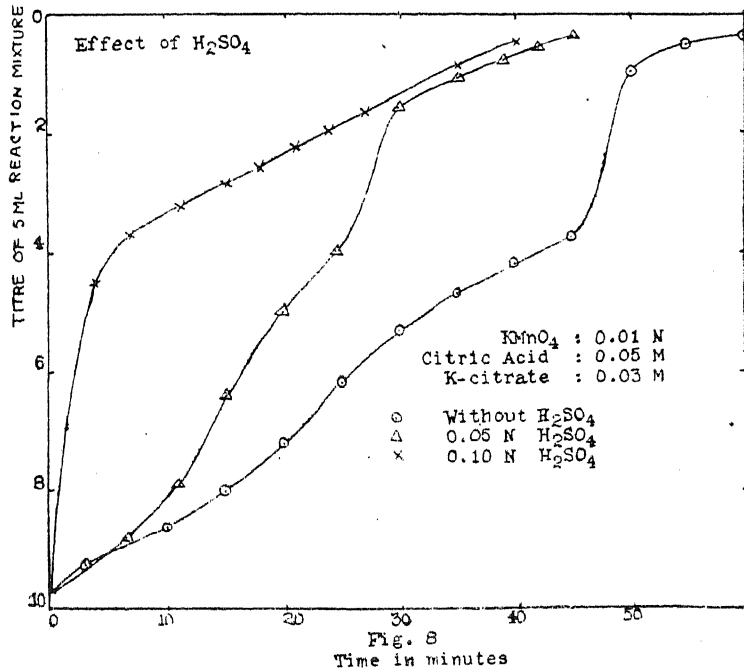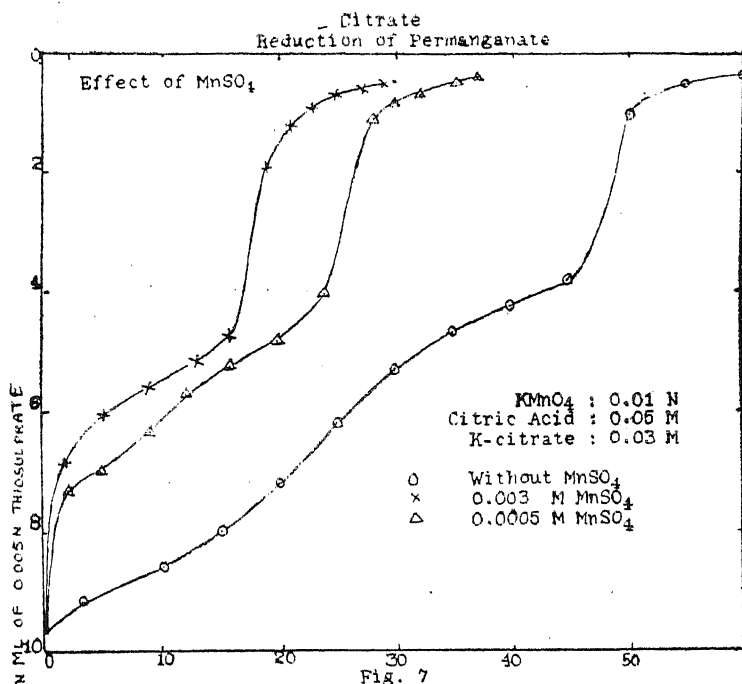
As would appear from figs. 1 and 2, the reaction with citric acid is quite fast. Hence mixtures of citric acid and potassium citrate have been employed whereby the hydrogen ion concentration could be kept low in order to obtain the exact nature of the $-d(oxidant)/dt$ curves. Fig. 3 gives the effect on the rate of reaction produced by small variations in pH. The rate increases with the increase in hydrogen ion concentration. The results with H_2SO_4 (fig. 8) also show this.

Fig. 7 shows that the reaction is very fast in presence of manganous sulphate. It is almost complete in 5 minutes in presence of $0.01M$ $MnSO_4$. Vanadium also is a good catalyst for this reaction (fig. 6).

From all these figures it is easily seen that the curves consist of two autocatalytic periods or two sigmoid curves, the latter being quite distinct and similar to those obtained in the oxidation of oxalate[5]. Gupta and Ghosh[6] reported that the first step of reduction of permanganate is sufficiently slow, resulting in induction period. This has been ascribed to want of manganous ions which are produced by the reduction of Mn(VII). If manganous ions are added initially, no such induction period is observed and permanganate reacts directly with Mn(II) producing Mn(VI) and Mn(III) according to the mechanism, $MnO_4^- + Mn^{2+} \rightleftharpoons MnO_4^{2-} + Mn^{3+}$. The two S shaped curves are caused by the fact that permanganate twice reacts with Mn(II). First a little of permanganate is slowly reduced to give a small concentration of Mn(II) which reacts with permanganate to give Mn(III) directly. Thus the rate of reaction increases for a while because the rates of reduction of Mn(VI) and Mn(III) are faster than the first step of reduction of permanganate. But most of the permanganate remains as such and is slowly reduced along with the reduction of MnO_4^{2-} and Mn^{3+}. Sufficient concentration of Mn(II) is now produced to react with most of the permanganate and the reaction becomes fast resulting in the steep portion of the curves. In presence of $0.0003M$ and $0.0005M$ $MnSO_4$, the first induction period disappears, but the second does not,

because the concentration of manganous sulphate is not sufficient to react with the whole of permanganate. In presence of 0·01M MnSO₄, both induction periods

Reduction of Permanganate by Citrate

Fig. 4

Fig. 5

Time in minutes

Fig. 6

Time in minutes

Citrate
Reduction of Permanganate

Effect of MnSO₄

KMnO₄ : 0.01 N
Citric Acid : 0.05 M
K-citrate : 0.03 M

O   Without MnSO₄
×   0.003 M MnSO₄
△   0.0005 M MnSO₄

Fig. 7

Effect of H₂SO₄

KMnO₄ : 0.01 N
Citric Acid : 0.05 M
K-citrate : 0.03 M

O   Without H₂SO₄
△   0.05 N H₂SO₄
×   0.10 N H₂SO₄

Fig. 8
Time in minutes

disappear for reasons stated above. The effect of hydrogen ion can be seen from fig. 3 where both the induction periods slowly disappear by decreasing the pH.

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Figs. 4 and 5 show the results under conditions where an attempt has been made to change the concentration of citrate without changing pH of the system. It may be seen that the rate is only slightly decreased by decreasing the concentra-

Reduction of MnO₂ by Citrate

Effect of changing the concn. of the acid

MnO₂ : 0.01N

⊙ 0.08M Cit. Acid
△ 0.04M Cit. Acid
× 0.02M Cit. Acid

Fig. 9   Time in minutes

Effect of changing the concn. of MnO₂

Citric Acid : 0.08 M

⊙ 0.01 N MnO₂
× 0.005N MnO₂

Fig. 10

Effect of pH

MnO₂ : 0.01 N

	Citric Acid	K-citrate	pH
▣	0.02 M	0.06 M	5.70
×	0.03 M	0.05 M	4.90
⊙	0.08 M	0	2.36
●	0.02 M	0.02 M	4.10
△	0.06 M	0.02 M	3.60

Fig. 11
Time in minutes
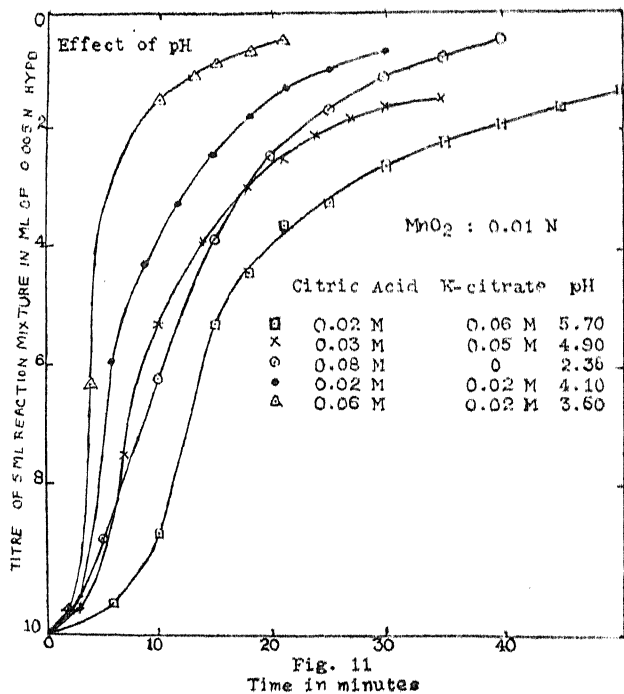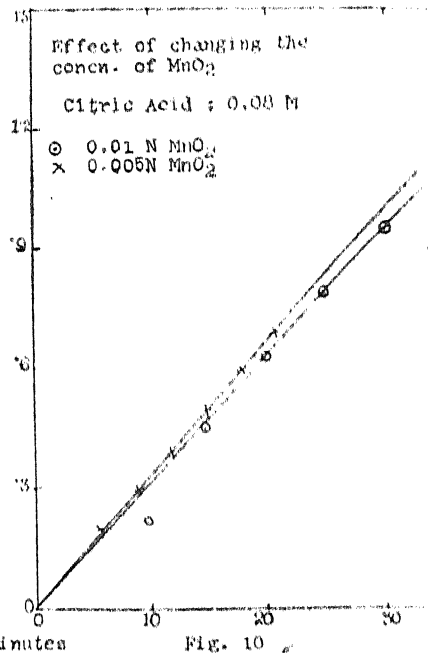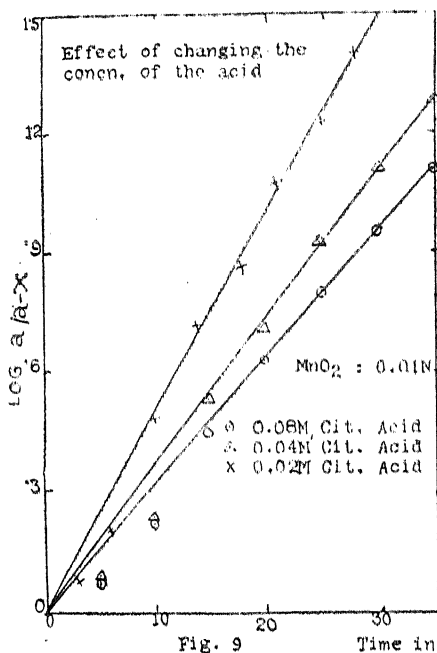
tion of the citrate, but this too, we believe, is due to the decrease in hydrogen ion concentration. It is difficult to keep a constant pH for noting the effect of citrate ion on the rate of reaction. We have already seen a reverse behaviour in the case of citric acid where no potassium salt has been used.

REACTION WITH MANGANESE DIOXIDE

Manganese dioxide dissolves in about 10 to 15 minutes to give a clear orange or yellow solution. The rate was found to be first order in oxidant (Mn^{3+}) and probably independent of concentration of citrate. The first order constants were calculated from the following relation, $k = 2\cdot303/t \times \log a/(a-x)$.
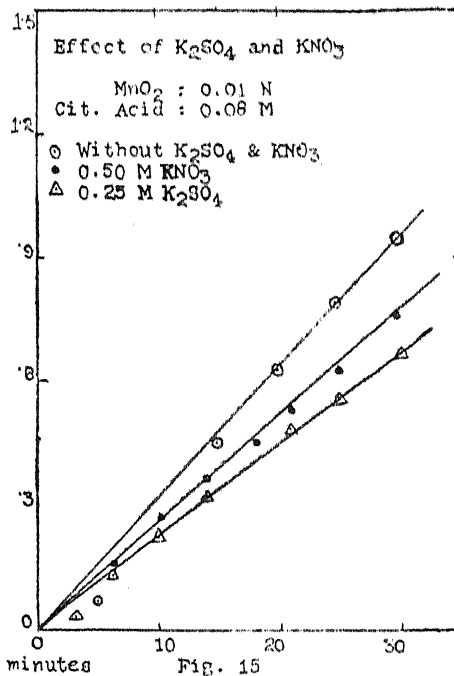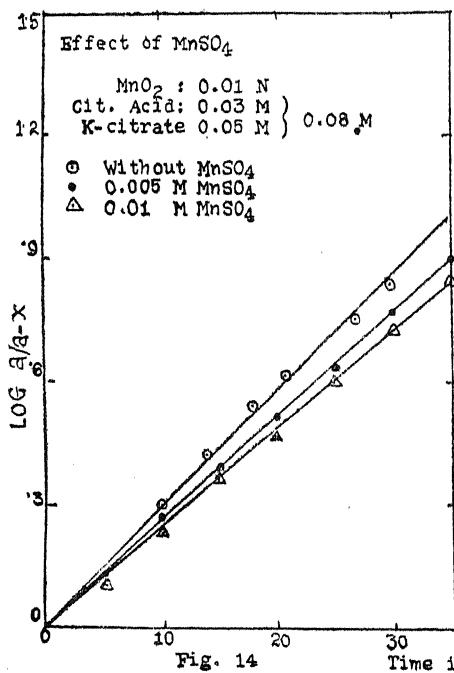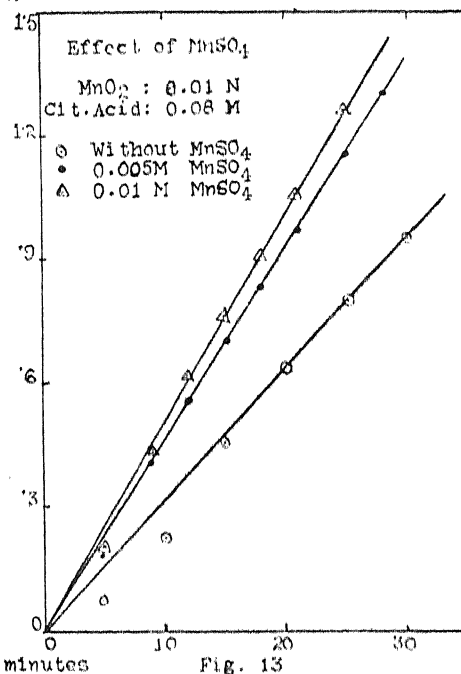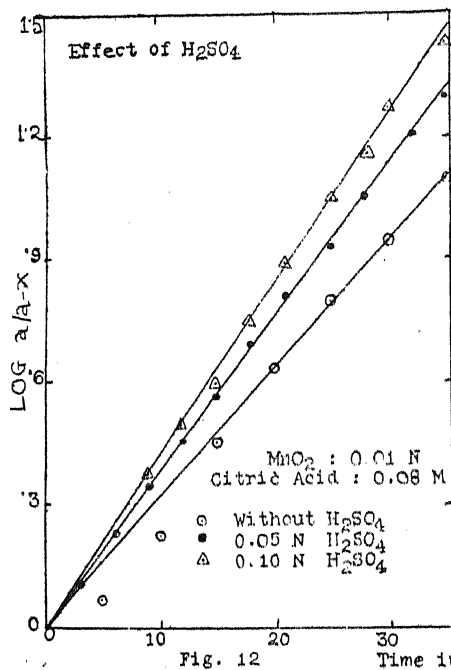
where a and $(a-x)$ are the concentrations of the oxidant initially and after time t. The reaction is not homogeneous in the beginning and hence first few readings have been ignored for calculating the average. Figs. 9, 10, 12, 13, 14 and 15 give a plot of $\log a/(a-x)$ against t. Straight lines are obtained in agreement with the first order equation. Fig. 10 also shows that the slope of the straight line remains almost the same by changing the concentration of MnO_2. Fig. 9 gives the same peculiar behaviour of citric acid as was found in case of permanganate. As it is very unlikely of the rate of reaction decreasing with the increase in the concentration of a reactant, it appears that perhaps pH of the solution plays an important role in this reaction. Hence mixtures of citric acid and potassium citrate were employed here also and the results are shown in fig. 11. There is an optimum pH in the range 2 – 6 for which the reduction of Mn(III) is fastest. It may also be seen from this figure that in the initial stages, the rate of reaction, which represents the dissolution of MnO_2, increases with the increase in the hydrogen ion concentration. In the reduction of permanganate by citric acid, the pH of the system is sufficiently low to bring about the quick reduction to Mn(III) state and therefore, we observe a sudden fall in the amount of oxidant. Thereafter it is a reduction of Mn(III) as in case of MnO_2. This explains the peculiar behaviour of citric acid towards the end of the reduction of permanganate. Table 1 shows that the rate is fastest at pH 3·5 and the reduction of Mn(III) may be independent of the concentration of citrate.

TABLE 1

MnO_2 : 0·01 N

Citric acid M	Pot. Citrate M	pH	$k \times 10^2$min.$^{-1}$
0·08	0	2·35	7·36
0·04	0	2·50	8·56
0·02	0	2·60	11·67
0·06	0·02	3·50	16·64
0·02	0·02	4·10	9·59
0·03	0·05	4·90	6·62
0·02	0·06	5·70	4·54

However, when sulphuric acid is used (fig. 12), pH falls below 2 and the rate increases with the increase in the concentration of H_2SO_4.

Reduction of MnO$_2$ by Citrate

Effect of H_2SO_4

MnO_2 : 0.01 N
Citric Acid : 0.08 M

⊙   Without H_2SO_4
●   0.05 N H_2SO_4
△   0.10 N H_2SO_4

Fig. 12

Effect of MnSO$_4$

MnO_2 : 0.01 N
Cit.Acid: 0.08 M

⊙   Without MnSO$_4$
●   0.005M MnSO$_4$
△   0.01 M MnSO$_4$

Fig. 13

Effect of MnSO$_4$

MnO_2 : 0.01 N
Cit. Acid: 0.03 M
K-citrate 0.05 M) 0.08 M

⊙   Without MnSO$_4$
●   0.005 M MnSO$_4$
△   0.01 M MnSO$_4$

Fig. 14

Effect of K_2SO_4 and KNO$_3$

MnO_2 : 0.01 N
Cit. Acid : 0.08 M

⊙   Without K_2SO_4 & KNO$_3$
●   0.50 M KNO$_3$
△   0.25 M K_2SO_4

Fig. 15

Time in minutes

[338]

The results in presence of $MnSO_4$ are shown in figs. 13 and 14. When citric acid is used, the rate increases, while in case of a mixture of citric acid and its potassium salt, it decreases. We believe that Mn(II) acts as an anticatalyst in the reaction as has been reported in case of oxalate[7], malonate[8] and malate[9]. The opposite behaviour of Mn(II) in case of citric acid (fig. 13) may be explained by assuming that the anticatalytic action of Mn(II) is masked at pH 2·35 or that $MnSO_4$ probably increases the pH, thus increasing the rate as per above table.
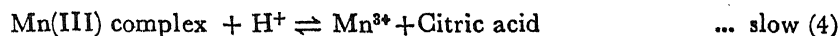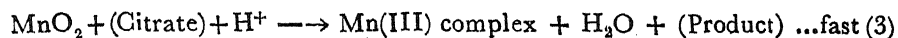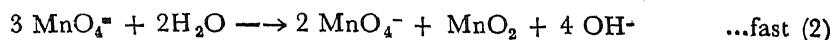
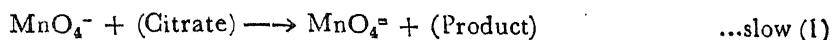*Energy and entropy of activation*:

Reaction with MnO_2 was studied also at 29°C and the average k was found to be $14·58 \times 10^{-2}$ min.$^{-1}$ with 0 08M of citric acid. Following calculations were made from this value of k and the value 7·36 of Table 1.

Energy of activation = 24290 cals.

Frequency factor = $1·04 \times 10^{15}$ sec.$^{-1}$

Mechanism:

Based on the above observations, we propose the following scheme for stepwise reduction of permanganate.

$$MnO_4^- + (Citrate) \longrightarrow MnO_4^= + (Product) \qquad ...slow\ (1)$$

$$3\ MnO_4^= + 2H_2O \longrightarrow 2\ MnO_4^- + MnO_2 + 4\ OH^- \qquad ...fast\ (2)$$

$$MnO_2 + (Citrate) + H^+ \longrightarrow Mn(III)\ complex + H_2O + (Product) \ ...fast\ (3)$$

$$Mn(III)\ complex + H^+ \rightleftharpoons Mn^{3+} + Citric\ acid \qquad ...\ slow\ (4)$$

$$Mn^{3+} + H_2O \rightleftharpoons Mn^{2+} + H^+ + OH \qquad ...\ slow\ (5)$$

$$Citrate + OH \longrightarrow Product \qquad ...\ fast\ (6)$$

The observed induction period is caused by the first slow step. Step (2) is fast because it is heterogeneous and is catalysed by MnO_2[10]. The medium being acidic, manganate immediately disproportionates into permanganate and manganese dioxide. We have already seen that the dissolution of manganese dioxide is fast and catalysed by hydrogen ions. The slow step (5) is first order in Mn(III), independent of citrate and anticatalysed by Mn(II). The last step may consist of a number of fast steps leading to the complete or partial oxidation of citrate. We have no kinetic evidence for step (4), but because Mn(III) cannot exist as such, it is reasonable to assume that it forms yellow or orange complex with citrate similar to oxalate and malonate complexes[11,12,13] Mn(III) can exist as trivalent positive ion only in high acid medium[14]. Hence the dissociation of the complex into Mn(III) and citrate ion, is catalysed by hydrogen ions. It may be seen that the hydrogen ions have opposite effects on steps (4) and (5) and that, probably is the reason for an optimum pH for which the reduction of Mn(III) is fastest. In presence of sulphuric acid, the effect of hydrogen ions on steps (3) and (4) is much more than that on step (5) and hence the rate of reaction continuously increases by increasing the concentration of sulphuric acid.

We know nothing about the oxidation stages of citrate, nor could we indentify the oxidation products. However, we titrated citric acid by $Mn_2(SO_4)_3$[14] in cold and found that each molecule of acid requires six equivalents of Mn(III).

Gupta and Ghosh[7] and Polissar[15] believe that the rapid equilibrium, $MnO_4^- + Mn^{2+} \rightleftharpoons MnO_4^= + Mn^{3+}$ is set up in presence of manganous sulphate; whereas Launer[16] and Bradley and Praagh[17] report that MnO_2 is formed according to the mechanism, $2\ MnO_4^- + 3\ Mn^{2+} + 2\ H_2O \rightarrow 5\ MnO_2 + 4\ H^+$. $MnO_4^=$ immediately gives MnO_2 and thus both mechanisms produce MnO_2. However, equilibrium, $MnO_4^- + Mn^{2+} \rightleftharpoons MnO_4^= + Mn^{3+}$ may be preferred on the basis of the one electron transfer rule[18]. It may also be seen from figs. 3 and 8 that the steep portion of the curves starts when the remaining oxidant fraction is nearly 2/5. Permanganate on 3/5 reduction exists in Mn(IV) state and we may conclude that at the beginning of the steep portion, oxidant is mostly in the form of MnO_2 The same may be observed in presence of manganous sulphate (fig. 7) and visually also, MnO_2 is seen to be produced on mixing the permanganate and manganous sulphate. Hence we may confirm that MnO_2 is definitely formed by the interaction of MnO_4^- and Mn(II).

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SUPERPOSABILITY IN MAGNETOHYDRODYNAMICS

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In the usual notation the basic equations of Magnetohydrodynamics are

$$\operatorname{curl} \vec{H} = 4\pi \vec{J} \qquad\qquad 0\cdot 1$$

$$\operatorname{curl} \vec{E} = -\mu \frac{\partial \vec{H}}{\partial t} \qquad\qquad 0\cdot 2$$

$$\vec{J} = \sigma(\vec{E} + \mu \vec{q} \times \vec{H}) \qquad\qquad 0\cdot 3$$

$$\frac{\partial \vec{q}}{\partial t} + \operatorname{curl} \vec{q} \times \vec{q} + \frac{\mu}{4\pi\rho} \vec{H} \times \operatorname{curl} \vec{H} + \operatorname{grad}\left(\frac{p}{\rho} + \frac{1}{2}\vec{q}^2 - \Omega\right) = \gamma \nabla^2 \vec{q} \qquad 0\cdot 4$$

$$\operatorname{div} \vec{q} = 0 \qquad\qquad 0\cdot 5$$

$$\operatorname{div} \vec{H} = 0 \qquad\qquad 0\cdot 6$$

From equations 0·1, 0·2 and 0·3, the equation governing the changes in the magnetic field is

$$\frac{\partial \vec{H}}{\partial t} = \operatorname{curl}(\vec{q} \times \vec{H}) + \eta \nabla^2 \vec{H} \qquad\qquad 0\cdot 7$$

where

$$\eta = (4\pi\mu\sigma)^{-1}$$

Equations 0·4 and 0·7 constitute the basic equations of motion of a viscous incompressible electrically conducting fluid in the presence of a magnetic field. The equations being non-linear any two solutions are not in general superposable. When $(\vec{q_1}, \vec{H_1}, p_1, \Omega_1)$ and $(\vec{q_2}, \vec{H}, p_2, \Omega_2)$ are any two solutions of the equations 0·4 to 0·7, these two solutions are defined to be superposable if $(\vec{q_1} + \vec{q_2}, \vec{H_1} + \vec{H_2}, p_1 + p_2 + \pi, \Omega_1 + \Omega_2)$ is also a solution of the system of equations 0·4 to 0·7. General conditions for superposability have been discussed by me in detail else where [2]. In the present note some specific flows are taken and the nature of the most general flows that are superposable on them is discussed. Some solutions are given in case of self-superposable flows. In the last section we have taken the equation of magnetohydro statics,

[341]

and the conditions for any two solutions to be superposable are discussed. It is also shown that force-free magnetic fields are a special case of a self-superposable field.

§ 1. The equations for the first two fields are

$$\frac{\partial \vec{Hi}}{\partial t} - \text{curl}\,(\vec{qi} \times \vec{Hi}) = \eta\,\nabla^2\,\vec{Hi} \qquad 1\cdot1$$

$$\frac{\partial \vec{qi}}{\partial t} + \text{curl}\,\vec{qi} \times \vec{qi} + \frac{\mu}{4\pi\rho}\,\vec{Hi} \times \text{curl}\,\vec{Hi} + \text{grad}\left(\frac{pi}{\rho} + \frac{1}{2}\,\vec{qi}^2 - \Omega i\right) = \gamma\,\nabla^2\,\vec{qi} \qquad 1\cdot2$$

$$(i=1,\,2)$$

The equations resulting from superposition are

$$\frac{\partial}{\partial t}\left(\vec{H_1} + \vec{H_2}\right) - \text{curl}\left[\left(\vec{q_1}\ \vec{q_2}\right) \times \left(\vec{H_1} + \vec{H_2}\right)\right]$$

$$= \eta\,\nabla^2\,(\vec{H_1} + \vec{H_2}) \qquad 1\cdot3$$

$$\frac{\partial}{\partial t}\left(\vec{q_1} + \vec{q_2}\right) + \text{curl}\left(\vec{q_1} + \vec{q_2}\right) \times \left(\vec{q_1} + \vec{q_2}\right) +$$

$$- \frac{\mu}{4\pi\rho}\,\text{curl}\left(\vec{H_1} + \vec{H_2}\right) \times \left(\vec{H_1} + \vec{H_2}\right) + \text{grad}\left(\frac{p_1 + p_2 + \pi}{\rho}\right)$$

$$+ \frac{1}{2}\left(\vec{q_1} + \vec{q_2}\right)^2 - \Omega_1 - \Omega_2\right) = \gamma\,\nabla^2\left(\vec{q_1} + \vec{q_2}\right) \qquad 1\cdot4$$

In view of the equations 1·1 and 1·2 the above equations give

$$\text{curl}\,(\vec{q_1} \times \vec{H_2} + \vec{q_2} \times \vec{H_1}) = 0 \qquad 1\cdot5$$

$$\text{curl}\,\vec{q_1} \times \vec{q_2} + \text{curl}\,\vec{q_2} \times \vec{q_1} - \frac{\mu}{4\pi\rho}\left(\text{curl}\,\vec{H_1} \times \vec{H_2}\right.$$

$$\left. + \text{curl}\,\vec{H_2} \times \vec{H_1}\right) + \text{grad}\left(\frac{\pi}{\rho} + \vec{q_1} \cdot \vec{q_2}\right) = 0 \qquad 1\cdot6$$

For self-superposability the conditions are

$$\text{curl}\,(\vec{q} \times \vec{H}) = 0 \qquad 1\cdot7$$

$$\text{curl}\left(\text{curl}\,\vec{q} \times \vec{q}\ \ \frac{-\mu}{4\pi\rho}\,\text{curl}\,\vec{H} \times \vec{H}\right) = 0 \qquad 1\cdot8$$

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The equations 0·4 and 0·7 in this case give

$$\frac{\partial \vec{H}}{\partial t} = \eta \, \Delta^2 \, \vec{H} \tag{1·9}$$

$$\frac{\partial \vec{\omega}}{\partial t} = \gamma \, \Delta^2 \, \vec{\omega} \tag{1·10}$$

$$\left(\vec{\omega} = \text{curl } \vec{q} \right)$$

§2. Two-dimentional motion. When the vectors $\vec{q}$ and $\vec{H}$ are two-dimentional we take them in the form

$$\vec{q}i = \left(-\frac{1}{r} \frac{\partial \Psi i}{\partial \theta}, \frac{\partial \Psi i}{\partial r}, 0 \right) \tag{2·1}$$

$$\vec{H}i = \left(\frac{-1}{r} \frac{\partial \phi i}{\partial \theta}, \frac{\partial \phi i}{\partial r}, 0 \right) \tag{2·2}$$

$$(i = 1,2)$$

The conditions 1·5 and 1·6 now give

$$\frac{\partial}{\partial \theta} \left[\frac{\partial (\Psi_1, \Phi_2)}{\partial (r_1 \, \theta)} + \frac{\partial (\Psi_2, \Phi_1)}{\partial (r_1 \, \theta)} \right] = 0 \tag{2·3}$$

$$\frac{\partial}{\partial r} \left[\frac{1}{r} \left\{ \frac{\partial (\Psi_1, \Phi_2)}{\partial (r_1 \, \theta)} + \frac{\partial (\Psi_2, \Phi_1)}{\partial (r_1 \, \theta)} \right\} \right] = 0 \tag{2·4}$$

$$= \frac{\partial (\Psi_1 \, \Delta^2 \, \Psi_2)}{\partial (r_1 \, \theta)} + \frac{\partial (\Psi_2, \Delta^2 \, \Psi_1)}{\partial (r_1 \, \theta)}$$

$$= \frac{\partial (\Phi_1, \Delta^2 \, \Phi_2)}{\partial (r_1 \, \theta)} + \frac{\partial (\Phi_2, \Delta^2 \, \Phi_1)}{\partial (r_1 \, \theta)} \tag{2·5}$$

where

$$\Phi i = \sqrt{\frac{\mu}{4 \pi \rho}} \, \phi i \;\; (i = 1,2)$$

$$\Delta^2 = \frac{\partial^2}{\partial r^2} + \frac{1}{r} \frac{\partial}{\partial r} + \frac{1}{r^2} \frac{\partial^2}{\partial \theta^2}$$

From 2·3 and 2·4 we obtain

$$\frac{\partial (\Psi_1, \Phi_2)}{\partial (r_1 \, \theta)} + \frac{\partial (\Psi_2, \Phi_1)}{\partial (r_1 \, \theta)} = g(r) \tag{2·6}$$

$$\frac{d}{dr} \left[\frac{g(r)}{r} \right] = 0 \tag{2·7}$$

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For self-superposability the conditions are

$$\frac{\partial\,(\Psi,\,\Phi)}{\partial\,(r_1\,\theta)} = \frac{1}{2}\,g(r) \qquad\qquad\qquad 2\cdot8$$

$$\frac{d}{dr}\left[\frac{g(r)}{r}\right] = 0 \qquad\qquad\qquad 2\cdot9$$

$$\frac{\partial\,(\Psi,\,\triangle^2\,\Psi)}{\partial\,(r_1\,\theta)} = \frac{\partial\,(\Phi,\,\triangle^2\,\Phi)}{\partial\,(r_1\,\theta)} \qquad\qquad\qquad 2\cdot10$$

J. Kampa de F'eriat [3] has studied the equation 1·10 and has given its solution in terms of the Fourier transform Z of defined as

$$Z\,(\omega_1,\,\omega_2,\,t) = \frac{1}{4\,\pi^2}\int_D \omega e^{-i\,(\omega_1\,x+\,\omega_2\,y)}\,dx\,dy$$

where D is the entire plane $-\infty < x < \infty$, $-\infty < y < \infty$, and the velocity $\vec{q}$ vanishes at infinity. Also

$$\omega\,(x,\,y\,t) = \frac{1}{4\,\pi^2}\int_X Z\,(\omega_1,\omega_2,\,t)e^{i\,(\omega_1\,x\,+\,\omega_2\,y)}\,d\,\omega_1\,d\,\omega_2$$

where X is the entire plane $-\infty < \omega_1 < \infty$, $-\infty < \omega_2 < \infty$.

The most general solution of $Z\,(\omega_1,\,\omega_2,\,t)$ is

$$Z\,(\omega_1,\,\omega_2,\,t) = Z_0\,(\omega_1,|\omega_2)\,e^{-\gamma\,(\omega_1{}^2\,+\,\omega_2{}^2)\,t} \qquad\qquad 2\cdot11$$

where $Z_0\,(w_1,\,w_2)$ is the value of $Z\,(w_1,\,w_2,\,t)$ at $t=0$. Similarly defining $\bar{Z}$ $(w_1\,w_2,\,t_1$, the Fourier transform of $\vec{J}\,(1/4\pi\,\text{curl}\,\vec{H})$ as

$$\bar{Z}\,(w_1,\,w_2,\,t) = \frac{1}{4\pi^2}\int_D j\,e^{-i\,(\omega_1 x+\omega_2 y)}\,dx\,dy$$

it is easy to show that

$$\bar{Z}\,(\omega_1,\,\omega_2,\,t) = \bar{Z}_0\,(\omega_1,\,\omega_2)\,e^{-\eta\,(\omega_1{}^2+\omega_2{}^2)t} \qquad\qquad 2\cdot12$$

The above equation shows the decay of the magnetic field in a self-superposable flow. The rate of decay depends upon other things the number η.

Cataldo Agostinelli has shown that [4]* the fields 2·1 and 2·2 satisfy the fundamental equations 0·4 and 0·7 if

$$\Psi i = -\frac{1}{2}\,Wi\,r^2 + \beta\,fi\,(r,\,\theta) \qquad\qquad\qquad 2\cdot13$$

$$\phi i = -\frac{1}{2}\,hi\,r^2 + fi\,(r,\,\theta),\,(i=1,2) \qquad\qquad 2\cdot14$$

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* The results mentioned in [4] were available to the author from Math. Rev., 18 (1957), p. 849.

where Wi and $h i$ are constants. The functions $f i$ (r,θ) satisfy either of the two conditions given below.

$$(a) \quad \nabla^2 f i = 0 \qquad\qquad\qquad\qquad 2\cdot15$$

$$(b) \quad \beta = a = \sqrt{\frac{\mu}{4\pi\rho}}$$

$$\nabla^2\left(\gamma \nabla^2 f i - (\mathrm{W}i - h i \alpha)\,\frac{\partial f i}{\partial\theta}\right) = 0 \qquad\qquad 2\cdot16$$

I have discussed the superposability of the equations when Ψi and ϕi are given as in 2·13 and 2·14 in may paper [2]. Therefore we shall now discuss only the self-superposability. Substituting Ψ and ϕ from 2·13 and 2·14 in 2·8 we have

$$(h\,\alpha - \mathrm{W})\,\frac{\partial f}{\partial\theta} = \frac{1}{2}\,g\,(r)$$

and from 2·9 we get

$$\frac{\partial^2 f}{\partial r\,\partial\theta} = 0 \qquad\qquad\qquad 2\cdot17$$

When $f\,(r,\,\theta)$ satisfies 2·5 it is easy to see that the condition 2·10 is identically satisfied. We thus get

$$f\,(r,\,\theta) - (\mathrm{A} + \mathrm{B}\log r) + a\theta + b$$

$$\vec{q} = \left(+\frac{\beta a}{r}\;,\; -\mathrm{W}r + \beta\frac{\mathrm{B}}{r}\;,\; 0\right)$$

$$\vec{\mathrm{H}} = \left(\frac{-a}{r}\;,\; -hr + \frac{\mathrm{B}}{r}\;,\; 0\right) \qquad\qquad 2\cdot18$$

The field 2·18 is always self-superposable.

We shall now consider the case when $f\,(r,\,\theta)$ satisfies the equation 2·16. Substituting Ψ and ϕ in 2·10 we have

$$(h\alpha - \mathrm{W})\,\frac{\partial}{\partial\theta}\,(\nabla^2 f) = 0$$

from 2·16 and the above equation we see that $f\,(r,\theta)$ is a biharmonic function. With the help of 2·17 we thus get

$$f\,(r,\,\theta) = r^2\,(\mathrm{A} + \mathrm{B}\log r) + c\log r + a\theta^3 + b\theta^2 + c\theta + d$$

and the corresponding self-superposable fields are

$$\vec{q} = \left[-\frac{\beta}{r}\,(3a\theta^2 + 2b\theta + c),\, -\mathrm{W}r + \beta\,(2r\,\mathrm{A}\log r\right.$$
$$\left. + (\mathrm{A} + 2\mathrm{B})\,r\, +\frac{c}{r}\,,\, 0\right]$$

$$\vec{\mathrm{H}} = \left[\frac{-1}{r}(3a\theta^2 + 2b\theta + c),\, -hr + 2r\,\mathrm{A}\log r\right.$$
$$\left. + r(\mathrm{A} + 2\mathrm{B}) + \frac{c}{r}\,,\, 0\right] \qquad\qquad 2\cdot19$$

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It is also easy to show that the folws $2 \cdot 18$ and $2 \cdot 19$ are superposable on one another.

§3.   We now take two special values of Ψ and ϕ as given by $2 \cdot 13$ and $2 \cdot 14$ and discuss the nature of the most general flows superposable on them.   Let us take

$$\Psi_1 = \beta m \log r \qquad\qquad 3 \cdot 1$$

$$\phi_1 = m \log r \qquad\qquad 3 \cdot 2$$

Substituting in $2 \cdot 6$ we get, in view of $2 \cdot 7$

$$\frac{\partial^2}{\partial r \partial \theta}\left(\frac{\Phi_2}{r^2}\right) = 0, \frac{\partial^2}{\partial r \partial \theta}\left(\frac{\Psi_2}{r^2}\right) = 0 \qquad\qquad 3 \cdot 3$$

Equation $2 \cdot 5$ gives

$$\frac{\partial}{\partial \theta}\left(\nabla^2 \Psi_2\right) = 0, \frac{\partial}{\partial \theta}\left(\nabla^2 \Phi_2\right) = 0 \qquad\qquad 3 \cdot 4$$

From $3 \cdot 3$ and $3 \cdot 4$ we get

$$\Psi_2 = A_1(r) + r^2 (a_1 \cos 2\theta + a_2 \sin 2\theta + a_3)$$

$$\Phi_2 = A_2(r) + r^2 (b_1 \cos 2\theta + b_2 \sin 2\theta + b_3)$$

Where $A_1(r)$ and $A_2(r)$ are arbitrary functions of r only.

As a second example let us take

$$\Psi_1 = \beta k \theta \qquad\qquad 3 \cdot 5$$

$$\Phi_1 = K \theta \qquad\qquad 3 \cdot 6$$

From $2 \cdot 6$ and $2 \cdot 7$ we get in this case

$$\frac{\partial}{\partial r}\left(\frac{1}{r} \frac{\partial \Psi_2}{\partial r}\right) = 0, \frac{\partial}{\partial r}\left(\frac{1}{r} \frac{\partial \Phi_2}{\partial r}\right) = 0 \qquad\qquad 3 \cdot 7$$

Equation $2 \cdot 5$ now gives

$$\frac{\partial}{\partial r}\left(\nabla^2 \Psi_2\right) = 0, \frac{\partial}{\partial r}\left(\nabla^2 \Phi_2\right) = 0 \qquad\qquad 3 \cdot 8$$

From the above two equations we get

$$\Psi_2 = A_1(\theta) + a_1 \theta + a_2$$

$$\Phi_2 = A_2(\theta) + b_1 \theta + b_2$$

4.   The Hydrostatic problem. The magnetic field prevailing under conditions of hydrostatic equilibrium is governed by the equation (Ref. [1]).

$$\frac{\mu}{4 \pi \rho} \operatorname{curl} \vec{H} \times \vec{H} = \operatorname{grad}(p + V) \qquad\qquad 4 \cdot 1$$

Proceeding as in section 1 we see that the condition for superposability of any two solutions $(\vec{H_1}, p_1, V_1)$, $(\vec{H_2}, p_2, V_2)$ is

$$\text{curl } \vec{B_1} \times \vec{B_2} + \text{curl } \vec{B_2} \times \vec{B_1} = \text{grad } (\pi) \qquad\qquad 4 \cdot 2$$

where

$$\vec{B_i} = \sqrt{\frac{\mu}{4 \pi \rho}}\ \vec{H}i \quad i = 1, 2)$$

and π is the adjusted pressure. For self-superposability the condition is

$$\text{curl } (\text{curl } \vec{B} \times \vec{B}) = 0 \qquad\qquad 4 \cdot 3$$

The above equation is identically satisfied when $\text{curl } \vec{B} = \alpha\, \vec{B}$, showing that force free magnetic fields are a special case of a self-superposable magnetic field. In two dimensions taking $\vec{B}$ in the form

$$\vec{B} = \left(-\frac{\partial \phi}{\partial y}\ ,\ \frac{\partial \phi}{\partial x}\ ,\ 0 \right)$$

the condition $4 \cdot 2$ and 4.3 become

$$\frac{\partial (\phi_1, \nabla^2 \phi_2)}{\partial (x, y)} + \frac{\partial (\phi_2, \nabla^2 \phi_1)}{\partial (x, y)}\ , = 0 \qquad\qquad 4 \cdot 4$$

$$\frac{\partial (\phi, \nabla^2 \phi)}{\partial (x, y)} = 0 \qquad\qquad 4 \cdot 5$$

If the first field is a force free magnetic field we get from $4 \cdot 4$

$$\frac{\partial (\phi_1, \nabla^2 \phi_2)}{\partial (x, y)} = 0 \qquad\qquad 4 \cdot 6$$

Dealing with a similar situation in hydrodynamics Ram Ballabh has shown that ϕ_1 is given by [5].

(i) $\alpha x + \beta y + \gamma$

(ii) $A \log \sqrt{ (Bx + c)^2 + (By + D)^2 }$

5. The axisymetrical case. We take the vector $\vec{B}$ in the form

$$\vec{B}i = \left(\frac{-1}{\bar{\omega}}\ \frac{\partial \phi i}{\partial \bar{\omega}} \right) \vec{i}x \ \dotplus\ \left(\frac{1}{\bar{\omega}}\ \frac{\partial \phi i}{\partial x} \right) \vec{i}\bar{\omega} + fi\, (x, \bar{\omega})\ \vec{i\omega} \qquad\qquad 5 \cdot 1$$
$$(i = 1, 2)$$

the condition $4 \cdot 2$ now gives the following equations.

$$\frac{1}{\bar{\omega}^2} \left[\frac{\partial \phi_1}{\partial x}\ E^2\, \phi_2 + \frac{\partial \phi_2}{\partial x}\ E^2\, \phi_1 + \frac{\partial}{\partial x}\ (\bar{\omega}^2 f_1 f_2) \right] = \frac{\partial \pi}{\partial x} \qquad\qquad 5 \cdot 2$$

$$\frac{1}{\bar{\omega}^2} \left[\frac{\partial \phi_1}{\partial \bar{\omega}}\ E^2\, \phi_2 + \frac{\partial \phi_2}{\partial \bar{\omega}}\ E^2\, \phi_2 + \frac{\partial}{\partial \bar{\omega}}\ (\bar{\omega}^2 f_1 f_2) \right] = \frac{\partial \pi}{\partial \bar{\omega}} \qquad\qquad 5 \cdot 3$$

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and

$$\frac{\partial \, (\phi_1, \, \bar{\omega}^2 \, f_2)}{\partial \, (x, \, \bar{\omega})} + \frac{\partial \, (\phi_2, \, \bar{\omega}^2 \, f_1)}{\partial \, (x, \, \bar{\omega})} = 0 \qquad 5 \cdot 1$$

where

$$E^2 = \frac{\partial^2}{\partial \, x^2} + \frac{\partial^2}{\partial \, \bar{\omega}^2} - \frac{1}{\bar{\omega}} \, \frac{\partial}{\partial \bar{\omega}}$$

The equation 5·2 and 5·3 together determine the adjusted pressure.

The two together can be written as

$$d \, (\pi) = \frac{1}{\bar{\omega}^2} \left[E^2 \, \phi_1 \, d \, \phi_2 + E^2 \, \phi_2 \, d\phi_1 + d \, (\bar{\omega}^2 \, f_1 f_2) \right] \qquad 5 \cdot 5$$

By cross differentiation we also get the following equation

$$\frac{\partial \, (\phi_1, \, E^2 \, \phi_2)}{\partial \, (x, \, \bar{\omega})} + \frac{\partial \, (\phi_2, \, E^2 \, \phi_1)}{\partial \, (x, \, \bar{\omega})} - \frac{2}{\bar{\omega}} \left[\frac{\partial \, \phi_1}{\partial \, x} \, E^2 \, \phi_2 \right.$$

$$\left. + \frac{\partial \, \phi_2}{\partial x} \, E^2 \, \phi_1 + \frac{\partial}{\partial x} \, (\bar{\omega}^2 \, f_1 f_2) \right] = 0 \qquad 5 \cdot 6$$

For self-superposability the conditions are

$$\frac{\partial \, (\phi, \, \bar{\omega} f)}{\partial \, (x, \, \bar{\omega})} = 0 \qquad 5 \cdot 7$$

$$\frac{\partial \, (\phi, \, E^2 \, \phi)}{\partial \, x, \, \bar{\omega})} - \frac{1}{\bar{\omega}} \left[2 \, \frac{\partial \, \phi}{\partial \, x} \, E^2 \, \phi + \frac{\partial}{\partial x} \, (\bar{\omega}^2 \, f^2) \right] \qquad 5 \cdot 8$$

In view of 5·7 we get from 5·2 and 5·3

$$\frac{\partial \, (\pi, \, \phi)}{\partial \, (x, \, \bar{\omega})} = 0 \qquad 5 \cdot 9$$

From 5·7 and 5·9 we obtain

$$\bar{\omega} f = F \, (\phi) \qquad 5 \cdot 10$$

$$\frac{\pi}{2} = G \, (\phi) \qquad 5 \cdot 11$$

Equation 5·5 now gives

$$E^2 \, \phi + F \, (\phi) \, F^1 \, (\phi) = G \, (\phi) \qquad 5 \cdot 12$$

In case of a force-free magnetic field the above equation gives

$$E^2 \, \phi + F \, (\phi) \, F^1 \, (\phi) = 0 \qquad 5 \cdot 13$$

S. Chandersakher [6] has completely solved the above equation for $F \, (\phi) = a$ linear function $= \alpha \, \phi$,

$$\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial \bar{\omega}^2} - \frac{1}{\bar{\omega}} \, \frac{\partial}{\partial \bar{\omega}} + \bar{\omega}^2 \right) \phi = 0$$

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in terms of the fundamental solutions

$$\phi_n = \left[A_n J_{n+3/2}(a^r) + B_n J_{-(n+3/2)}(a\,r) \right] r^{-3/2} P_n^{3/2}(\cos\theta)$$

where $r\cos\theta = x$, $r\sin\theta = \bar{\omega}$, A_n, B_n are arbitrary constants and $P_n^{3/2}(\cos\theta)$ denotes the ultraspherical polynomial. The corresponding magnetic field is

$$\vec{B} = \left(\frac{-1}{r} \frac{\partial \phi_n}{\partial r} + \frac{\cot\theta}{r^2} \frac{\partial \phi_n}{\partial\theta} \right) \vec{i_x} + \left(\frac{\cot\theta}{r} \frac{\partial \phi_n}{\partial r} - \frac{1}{r^2} \frac{\partial \phi_n}{\partial\theta} \right) \vec{i_{\bar\omega}}$$

$$+ \left(\frac{\alpha\, \phi_n}{r\sin\theta} \right) \vec{i_{\omega}}$$

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ON THE GENERAL UNIQUENESS THEOREM IN ORDINARY DIFFERENTIAL EQUATIONS

By

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F. Brauer and S. Sternberg [1] have proved that solutions of ordinary Differential Equations will be unique under a set of conditions which are extended generalisations of Kamke's and Osgood's conditions. We shall attempt to establish uniqueness under conditions which are generalisations again. Incidentally we shall prove that the contravention of these conditions under some more restrictions will result in the non-uniqueness of the solutions.

1. Consider the ordinary Differential Equation

$$x'(t) = f(x,t), \qquad x(0) = 0 \tag{1}$$

where x and f are real valued functions.

Let $V(x,t)$ be a function defined for real t and real x and its powers, with non-negative real values, continuous in (x,t), having one sided partial derivatives with respect to t and x and such that $V(x,t) = 0 \to x = 0$. Let V_t and V_x denote the partial derivatives with respect to t and x respectively.

Theorem : Let $w(r,t)$ be continuous, non-negative function defined on $r \geqslant 0, 0 < t \leqslant a$; suppose the only solution of

$$r'(t) = w(r,t) \tag{2}$$

which satisfies $r(0) = r'(0) = 0$ (3)

on $0 \leqslant t \leqslant \zeta$ for any ζ in $0 < \zeta < a$, is the identically zero solution. Let $f(x, t)$ be continuous on a bounded region $0 < t < a$, $V(x,t) < b$ and

$$V_t((x-y)^\alpha, t) + a(x-y)^{\alpha-1} V_x((x-y)^\alpha, t) |f(x,t) - f(y,t)|$$

$$\leqslant w(V(x-y)^\alpha, t), t) \tag{4}$$

where $a \geqslant 1$.

Then there is at most one solution of (1) on $0 \leqslant t \leqslant a$.

Proof : Suppose $x_1(t)$, $x_2(t)$ to be 2 solutions of (1), if possible. Let $z(t) = x_1(t) - x_2(t)$, so that

$$z'(t) = f(x_1(t), t) - f(x_2(t), t) \tag{5}$$

Let $m(t) = V(z^\alpha, t)$ and $m^*(t) = \underset{h \to 0}{\text{Lim Sup}} (m(t) - m(t-h))/h$

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Then $(m(t) - m(t-h))/h = V(z^\alpha(t), t) - V(z^\alpha(t-h), t)$

$$+ V(z^\alpha(t-h), t) - V(z^\alpha(t-h), t-h)/h$$

Since V has one-sided partial derivatives the left hand side of the above equation is bounded by a sum of the form

$$(\alpha z^{\alpha-1}(t) V_x(z^\alpha, t) + \varepsilon_1)(z(t) - z(t-h))/h + V_t(z^\alpha, t) + \varepsilon_2$$

where $\varepsilon's$ tend to zero as h tends to zero.

Now allowing $h \to 0$ we obtain, in view of (4) and (5) that

$$m^*(t) \leqslant w(m(t), t) \qquad (6)$$

Let us now assume that there exists a ξ, $0 < \xi < a$ such that $m(\xi) > 0$. We can then find the minimum solution $k(t)$ of (2) through $(\xi, m(\xi))$ existing on some interval to the left of ξ. We shall show that as far to the left of ξ, that $k(t)$ exists it must be such that $0 < k(t) < m(t)$. $\qquad (7)$

To prove this we observe that $k(t)$ must necessarily be positive, for otherwise if $k(t) = 0$ at a point it could be continued to the interval $0 \leqslant t < \xi$ as a solution of (2) and (3) and hence $k(t)$ must vanish identically.

Now consider the solution $k(t, \varepsilon)$ of the equation

$$r'(t) = w(r(t), t) + \varepsilon, \ k(\xi) = m(\xi) \qquad (8)$$

which we know exists for sufficiently small $\varepsilon > 0$, as far to the left of ξ as $k(t)$ exists. Moreover

$$\text{Lim } k(t, \varepsilon) = k(t) \ [2]$$
$$\varepsilon \to +0$$

Thus to prove (7) it suffices to establish that

$$k(t, \varepsilon) \leqslant m(t) \qquad (9)$$

for all $\varepsilon > 0$ and all solutions of (8). If this were false, there must be a least upper bound η of numbers $t \leqslant \eta$ for which (9) is not true. Since $m(\xi) = k(\xi) = k(\xi, \varepsilon)$ and the functions $m(t)$, $k(t, \varepsilon)$ are continuous, it follows

$$m(\eta) = k(\eta, \varepsilon); m^*(\eta) \geqslant k'(\eta, \varepsilon) \qquad (10)$$

Thus in view of (6), (8) and (10)

$$w(m(\eta), \eta) + \varepsilon = w(k(\eta, \varepsilon), \eta) + \varepsilon$$
$$\leqslant m^*(\eta) \leqslant w(m(\eta), \eta)$$

and we arrive at a contradiction. This contradiction proves (9) which implies (7).

Now $k(t)$ can be continued to the whole interval $0 < t \leqslant \xi$ as a solution of (2) subject to the inequality (7).

Since $\text{Lim } m(t) = 0 \ \text{Lim } k(t) = 0$ we may define $k(0) = 0$.
$\qquad t \to +0 \qquad t \to +0$

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Again since $f(x,t)$ is continuous at the origin

$$| x_2(t) - x_1(t) | = | \int_0^t f(x_2(s), s) - f(x_1(s), s) \, ds | < \theta t$$

when $0 < t < \delta$ for any $\theta > 0$ and δ a small positive quantity.

Since V is also continuous this means that given any $\varepsilon > 0$, we can find a $\delta > 0$ such that $V(z^\alpha(t), t) < \varepsilon t$ for $0 < t < \delta$.

Thus $0 < m(t)/t < \varepsilon$ for $0 < t < \delta$ and $\underset{t \to +0}{\text{Lim}} \dfrac{m(t)}{t} = 0$

which means $k'(0) = 0$.

Thus $k(t)$ is a solution of (2) satisfying (3) and hence is identically zero on $0 \leqslant t \leqslant \xi$ contradicting the choice of $k(\xi)$.

Hence $x_1(t) \equiv x_2(t)$ on $0 \leqslant t < a$ which is the desired result.

The result due to F. Brauer and S. Steinberg referred to earlier is for a system of differential equations but with $\alpha = 1$.

Again putting $V(x,t) = x$ (4) becomes

$$\alpha (x-y)^{\alpha - 1} | f(x,t) - f(y,t) | \leqslant w((x-y)^\alpha, t) \tag{11}$$

If in (11) $a = 1$, we get Kamke's result, viz. if $r(t) \equiv 0$ is the only solution of $r'(t) = w(r,t)$, $r(0) = r'(0) = 0$ and $| f(x,t) - f(y,t) | \leqslant w((x-y), t)$, then the solution is unique.

2. We now pass on to the non-uniqueness result. We consider only the case $\alpha = 1$.

Let $V(x,t)$ satisfy the same conditions as before and $V(x,t) \neq 0$ imply $x \neq 0$. Let $w(r,t)$ and $f(x,t)$ have the same meaning as before.

Theorem : Let $k(t) > 0$ be a differentiable function on $0 < t < a$ which satisfies $r'(t) = w(r,t)$ in $0 < t < a$ and such that $k'(0)$ exists and $k(0) = k'(0) = 0$.

Let $V_t(x-y, t) + V_x(x-y, t) | f(x,t) - f(y,t) | > w(V(x-y, t), t) \tag{12}$ then (1) has got two solutions.

Proof : The proof will be carried over in two stages.

Suppose first that for $x = 0$

$$f(0,t) \equiv 0 \text{ in } | t | < a \tag{13}$$

In the inequality (12) put $y = 0$ it becomes

$$V_t(x,t) + V_x(x,t) | f(x,t) | > w(V(x,t), t) \tag{14}$$

Let $k(t_0) = \delta > 0$ for $0 > t_0 > a$

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Now consider the solution $x(t,\varepsilon)$ of the equation

$$x'(t) = f(x,t) + \varepsilon \tag{15}$$

$$x(t_0) = k(t_0)$$

where ε is an arbitrarily small positive quantity.

If $x(t)$ is a solution of (1) then $x(t) = \operatorname*{Lim}_{\varepsilon \to 0} x(t,\varepsilon)$

We can always choose a solution of (1) passing through $(k(t_0), t_0)$ which is non-negative in $0 < t_0 < a$. For if $x(t)$ is negative in $0 < t < t_1 < t_0$ then we can select that portion of $x(t)$ between t_1 to t_0 and combine it with $x \equiv 0$ in the other region. We will now prove that this newly formed function is a solution of (1) through $(0,0)$.

For if $m(t) = V(x,t)$, we can easily verify that $m'(t) > w(m(t), t)$ in view of (14). Proceeding on lines similar to the case of (7) we can see that $0 < m(t) < k(t)$. But since $k(0) = k'(0) = 0$ it follows that $m(0) = m'(0) = 0$. This implies that $x(0) = x'(0) = 0$. Thus equation (1) has a solution through $(0,0)$ which is not equal to zero. But since (13) holds $x \equiv 0$ is also a solution of (1) through $(0,0)$. Thus equation (1) has two solutions passing through $(0,0)$.

We now remove the restriction (13). Let $x_1(t)$ be a solution of (1) through $(0,0)$. Let $z(t) = x_1(t) - x_2(t)$ where $x_2(t)$ is another solution. Then

$$z' = x'_1 - x'_2 = f(x_1, t) - f(x_2, t)$$
$$= f(z + x_2, t) - f(x_2, t)$$
$$= F(z,t) \text{ (say)} \tag{16}$$

Now $F(0,t) = f(x_2,t) - f(x_2,t) \equiv 0$ for all t.

Our previous considerations show that equation (16) has two solutions through $(0,0)$. Thus $x_1(t)$ is not identically equal to $x_2(t)$. Thus equation (1) admits of plurality of solutions which proves the theorem.

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A NOTE ON SOME SELF-RECIPROCAL FUNCTIONS

By

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1. In a recent paper [1] V. Lakshmikanth tried to establish the self-reciprocity of the product of Bessel functions under Hankel transform. In this note the authors prove the results in [1] to be wrong and give a new self-reciprocal function in the form of product of two Bessel functions.

2. Let $\int_0^\infty (xt)^{1/2} J_\nu (xt) g(t) \, dt = \phi(x)$ 　　　　　　(2·1)

If $\phi(x) = g(x)$, then $g(x)$ is said to be self-reciprocal under Hankel transform of order ν. This implies that if $g(x)$ is self-reciprocal function of order ν then $g(x)$ and $\phi(x)$ must be identical.

V. Lakshmikanth under equation (6) of his paper [1] claims that

$$g(x, z_1 z_2 \ldots z_n) = \prod_{i=1}^{n} J_{ki} \left[a_i (x^2 + z_i^2)^{\frac{1}{2}} \right] (x^2 + z_i^2)^{-k_i/2} x^{\frac{1}{2}}$$

　　　　　　(2·2)

is R_1 for fixed values of $z_1, z_2, \ldots z_n$. Also from equation (5) in [1] we have

$$\int_0^\infty J_1 (xt) g(t, z_1, z_2, \ldots z_n) (xt)^{\frac{1}{2}} \, dt = \prod_{i=1}^{n} J_{ki} (a_1 z_i) z_i^{-k_1} x^{-\frac{1}{2}}$$

　　　　　　(2·3)

If the expression in (2·2) is R_1 then from (2·1) and (2·3) we must have

$$\prod_{i=1}^{n} J_{k_i} \left[a_i (x^2 + z_i^2)^{\frac{1}{2}} \right] (x^2 + z_i^2)^{-k_i/2} x^{-1/2} = \prod_{i=1}^{n} J_{k_i} (a_1 z_i) z_i^{-k_1} x^{-1/2}$$

　　　　　　(2·4)

which is absurd. Hence all the results in [1] are wrong.

Moreover the result in Equation (7) in [1] can independently be seen to be erraneous even in the simple case $n=1$ and $k_i=0$ by the result [2]

$$\int_0^\infty (xy)^{1/2} J_r (xy) x^{-1/2} J_{\nu-1} (ax) \, dx = 0, \quad 0 < y < a,$$

$$= a^{\nu-1} y^{-\nu+1/2}, \quad a < y < \infty \qquad (2·5)$$

3. Now it is proposed to prove that

$$x^{1/2} J_{k_1} (a_1 x) J_{k_2} (a_2 x) \qquad \text{is } R_\nu \text{ if}$$

$$k_1 = k_2 = \tfrac{1}{2} \nu \text{ and } a_1^2 - a_2^2 = 2.$$

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Proof: Titchmarsh [3] gives that $f(x)$ is R_v provided its Mellin transform is of the form $2^{\frac{1}{2}s}\,\Gamma\,(s/2+v/2+1/4)\,\phi\,(s)$ where $\phi\,(s)$ satisfies the functional relation $\phi\,(s) = \phi\,(1-s)$.

Watson [5] proves that $\int_0^\infty J_v\,(at)\,J_v\,(b\,t)\,t^{-\lambda}\,dt$

$$= \frac{(ab)^v\,\Gamma\,(v+1/2-\lambda/2)\,2^{-\lambda}}{(a^2+b^2)^{v\,+1/2-\lambda/2}\,\Gamma\,(v+1)}\,{}_2F_1\,(v/2+1/4-\lambda/4,\;v/2+3/4-\lambda/4,\;v+1\;;$$

$$\frac{-4a^2\,b^2}{(a^2+b^2)^2}\Bigg) \tag{3.1}$$

whether $a > b$ or $a < b$ and $R\,(2v+1) > R\,(\lambda) > -1$

Putting $\lambda = 1-s$ in (3.1) we have that

$$\int_0^\infty J_v\,(at)\,J_v\,(b\,t)\,t^{s-1}\,dt = \frac{(ab)^v\,\Gamma\,(v+s/2)\,2^{s-1}}{(a^2+b^2)^{v+s/2}\,\Gamma\,(v+1)}$$

$$\times\;{}_2F_1\,(v/2+s/4,\;v/2+s/4+1/2\;;\;v+1\;;\;-4a^2\,b^2/(a^2+b^2)^2\,) \tag{3.2}$$

Taking $v = v/2$ and $a = \sqrt 2 \cosh\,\theta$, $b = \sqrt 2 \sinh\,\theta$ *i.e.* $a^2 - b^2 = 2$ and using the relation given by Bailey [4] $F\,(a,\,b,\,c,\,z) = (1-z)^{-a}\,F\,(a,\,c-b,\,c,\,z/(z-1)$ and introducing parameters in Mellin Transform [6] we get that the Mallin Trans. form of $x^{\frac{1}{2}}\,J_{v/2}\,(\sqrt 2 \cosh\,\theta\,x)\,J_{v/2}\,(\sqrt 2 \sinh\,\theta\,x)$ is $2^{\frac{1}{2}s}\,\Gamma\,(v/2+s/2+1/4)\,\phi\,(s)$

where $\phi\,(s) = 2^{v/2-3/4}\,(\cosh\theta\;\sinh\theta)^v\,{}_2F_1\,[v/4+s/4+1/8.\;v/4-s/4+3/8\;;\;v/2+1\;;]$
$(4\sinh^2\,\theta\,\cosh^2\,\theta)/(\cosh^4\,\theta+\sinh^2\theta+6\sinh^2\,[\theta\,\cosh^2\,\theta].$

Since $F\,(a,\,b;\,c;\,z)$ is symmetric about a and b we have that $\phi\,(s)$ satisfies the functional relation $\phi\,(s) = \phi\,(1-s)$

Hence we get that $x^{\frac{1}{2}}\,J_{v/2}\,(\sqrt 2 \cosh\,\theta\,x)\,J_{v/2}\,(\sqrt 2 \sinh\,\theta\,x)$ is R_v.

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ON SOME IDENTITIES IN PARTITION FUNCTIONS

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Ramanujan (1) found the generating function for p (5n) and p (7n).

Kolberg, oddmund (2) found the generating function for p (3n).

Here I shall find the generating functions for p (3n), p (3n+1), p (3n+2).

The generating function for p (3n) is simpler than that given by Kolberg.

We know (3)

$$\sum_{0}^{\infty} p\,(n)\,x^n = \frac{1}{f\,(x)}$$

where $f\,(x) = \prod_{n=1}^{\infty} (1-x^n) = \sum_{n=-\infty}^{\infty} (-1)^n\, x^{n\,(3n+1)/2}$

and $|x| < 1$

Hence $\sum_{0}^{\infty} p\,(3n)\,x^{3n} + \sum_{0}^{\infty} p\,(3n+1)\,x^{3n+1}$

$$+\sum_{0}^{\infty} p\,(3n+2)\,x^{3n+2} = \frac{1}{f\,(x)} \qquad\qquad \ldots\ldots(1)$$

Now putting wx, w^2x for x where $1, w, w^2$ are cubic roots of unity we have

$$\sum_{0}^{\infty} p\,(3n)\,x^{3n} + w \sum_{0}^{\infty} p\,(3n+1)\,x^{3n+1}$$

$$+w^2 \sum_{0}^{\infty} p\,(3n+2)\,x^{3n+2} = \frac{1}{f\,(wx)} \qquad\qquad \ldots\ldots(2)$$

and $\quad \sum_{0}^{\infty} p\,(3n)\,x^{3n} + w^2 \sum_{0}^{\infty} p\,(3n+1)\,x^{3n+1}$

$$+ w \sum_{0}^{\infty} p\,(3n+2)\,x^{3n+2} = \frac{1}{f\,(w^2x)} \qquad\qquad \ldots\ldots(3)$$

Hence

$$3 \sum_{0}^{\infty} p\,(3n)\,x^{3n} = \frac{1}{f\,(x)} + \frac{1}{f\,(xw)} + \frac{1}{f\,(xw^2)}$$

$$3 \sum_0^\infty p(3n+1)\, x^{3n+1} = \frac{1}{f(x)} + \frac{w^2}{f(xw)} + \frac{w}{f(xw^2)}$$

$$3 \sum_0^\infty p(3n+2)\, x^{3n+2} = \frac{1}{f(x)} + \frac{w}{f(xw)} + \frac{w^2}{f(xw^2)}$$

Now $\dfrac{1}{f(xw)} = \dfrac{f(x)\, f(xw^2)}{f(x)\, f(xw)\, f(xw^2)}$

Again $f(x)\, f(xw)\, f(xw^2)$

$$= \prod_1^\infty (1-x^n)\ \prod_1^\infty (1-w^n x^n)\, \prod_1^\infty (1-w^{2n} x^n)$$

$$= \left[\prod_1^\infty (1-x^{3n}) \right]^3 \prod_0^\infty (1-x^{3n+1})\, \prod_0^\infty (1-wx^{3n+1}) \times$$

$$\prod_0^\infty (1-w^2 x^{3n+1})\, \prod_0^\infty (1-x^{3n+2})\, \prod_0^\infty (1-w^2 x^{3n+2}) \times$$

$$\prod_0^\infty (1-wx^{3n+2}) = \left[\prod_1^\infty (1-x^{3n}) \right]^3 \times$$

$$\prod_0^\infty (1-x^{9n+3})\, \prod_0^\infty (1-x^{9n+6}) = \frac{[f(x^3)]^4}{f(x^9)}$$

Hence $\dfrac{1}{f(xw)} = \dfrac{f(x^9)\, f(x)\, f(xw^2)}{[f(x^3)]^4}$

and $\dfrac{1}{f(xw^2)} = \dfrac{f(x^9)\, f(x)\, f(xw)}{[f(x^3)]^4}$

Let $\phi_1(x) = f(w^2 x) + f(wx)$

$$= \sum_{n=-\alpha}^\infty (-1)^n\, x^{n(3n+2)/2} \left[\frac{n}{w^2}(3n+1) + w^{n(3n+1)} \right]$$

$$= 2 + x + x^2 - x^5 - x^7 - 2x^{12} - 2x^{15}$$

Similarly $\phi_2(x) = w^2 f(w^2 x) + w f(wx)$

$$= -1 + x - 2x^2 + 2x^5 - x^7 + x^{12} + x^{15} \ldots\ldots$$

and $\phi_3(x) = w f(w^2 x) + w^2 f(wx)$

$$= -1 - 2x + x^2 - x^5 + 2x^7 + x^{12} + x^{15} \ldots\ldots$$

Hence we have $\phi_1(x) + \phi_2(x) + \phi_3(x) = 0$

$$3 \sum_0^\infty p(3n)\, x^{3n} = \frac{1}{f(x)} + \frac{f(x^9)\, f(x)\, \phi_1(x)}{f^4(x^3)} \qquad \ldots\ldots(4)$$

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$$3 \sum_{0}^{\alpha} p(3n+1) x^{3n+1} = \frac{1}{f(x)} + \frac{f(x^9) f(x) \phi_2(x)}{f^4(x^3)} \qquad \ldots\ldots(5)$$

$$3 \sum_{0}^{[\infty]} p(3n+2) x^{3n+2} = \frac{1}{f(x)} + \frac{f(x^9) f(x) \phi_3(x)}{f^4(x^3)} \qquad \ldots\ldots(6)$$

It is interesting to note that

$$\frac{f(x^9) f(x) \phi_1(x)}{f^4(x^3)} = 2 \sum_{n=0}^{\infty} p(3n) x^{3n}$$

$$= \sum_{n=0}^{\infty} p(3n+1) x^{3n+1}$$

$$= \sum_{n=0}^{\infty} p(3n+2) x^{3n+2} \qquad \ldots\ldots(7)$$

$$\frac{f(x^9) f(x) \phi_2(x)}{f^4(x^3)} = 2 \sum_{n=0}^{\infty} p(3n+1) x^{3n-1}$$

$$= \sum_{n=0}^{\infty} p(3n) x^{3n}$$

$$= \sum_{n=0}^{\infty} p(3n+2) x^{3n+2} \qquad \ldots\ldots(8)$$

$$\frac{f(x^9) f(x) \phi_3(x)}{f^4(x^3)} = 2 \sum_{n=0}^{\infty} p(3n+2) x^{3n+2}$$

$$= \sum_{n=0}^{\infty} p(n) x^{3n}$$

$$= \sum_{n=0}^{\infty} p(3n+1) x^{3n+1} \qquad \ldots\ldots(9)$$

Using the identity

$$(a + b + c) \quad (a + bw + cw^2) \quad (a + bw^2 + cw)$$
$$= a^3 + b^3 + c^3 - 3 abc$$

and multiplying both the sides of (1), (2), (3)

We have

$$\left[\sum_{n=0}^{\infty} p\,(3n)\,x^{3n} \right]^3 + \left[\sum_{n=0}^{\infty} p\,(3n+1)\,x^{3n+1} \right]^3$$

$$+\left[\sum_{n=0}^{\infty} p\,(3n+2)\,x^{3n+2} \right]^3 - 3\left[\sum_{n=0}^{\infty} p\,(3n)\,x^{3n} \right] \times$$

$$\left[\sum_{n=0}^{\infty} p\,(3n+1)\,x^{3n+1} \right]\left[\sum_{n=0}^{\infty} p\,(3n+2)\,x^{3n+2} \right]$$

$$=\frac{f\,(x^9)}{f^4\,(x^3)}=f\,(x^9)\left[\sum_{n=0}^{\infty} p\,(n)\,x^{3n} \right]^4 \qquad\qquad \ldots\ldots(10)$$

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ROTATORY DISPERSION OF D - AND L - ETHANOLAMINO CAMPHOR-β-SULPHONATE

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ABSTRACT

Ethanolamine salts of D- and L- camphor-β-sulphonic acid have been prepared and characterised. Their rotatory dispersion has been studied in water, methyl alcohol, ethyl alcohol, chloroform and pyridine. In each solvent they exhibit simple dispersion in the visible region. The effect of ethanol group on rotatory power in different solvents has been discussed.

INTRODUCTION

In an earlier communication[1] the authors have described the rotatory dispersion of active ethylamino camphor-β-sulphonates. The present work is an extension of the earlier work and describes the rotatory dispersion of D- and L- ethanolamino camphor-β-sulphonates in different solvents. The influence of the ethanol group on optical rotatory power in the derivatives of D- and L- camphor-β-sulphonic acids has also been discussed.

EXPERIMENTAL

D-camphor-β-sulphonic acid used was prepared from natural D-camphor as described previously by one of us[2]. In a like manner L-camphor-β- sulphonic acid was prepared from L-camphor obtained by the oxidation of L-*iso*-borneol.

Ethanolamino-camphor-β-sulphonates :

6 g. of D- or L- camphor-β-sulphonic acid was condensed with 1·57 g. of ethanolamine in anhydrous ethyl acetate medium. The product obtained was recrystallised from a mixture of benzene and alcohol. For D-salt-yield 6·5g. m.p. 132°; S = 10·86%. For L-salt-yield 6·4 g., m.p. 132°; S = 11·12%. $C_{10}H_{15}OSO_3$ $H.H_2N.CH_2.CH_2.OH$ requires S = 10·92%.

The salts are white crystalline solids. They are highly soluble in water, methyl alcohol, ethyl alcohol, pyridine, acetone, carbon tetrachloride; sparingly soluble in ethyl acetate, ether and petroleum ether and practically insoluble in benzene.

The rotatory power measurements were carried out in a 2 dcm. tube in different solvents. For the sake of comparison approximately similar concentrations and temperature were used and the measurements were carried out for the same twelve lines in the visible range of the spectrum. It may be mentioned that in twenty four hours no appreciable change in rotatory power was observed. The values of specific rotations observed are recorded in Table 1. The data in Table 1 was analysed both graphically and mathematically according to the method given by Lowry[3]. It was found that in each case the rotatory dispersion is simple and can be satisfactorily expressed by Drude's one term equation. The equations thus found out are given in Table 1.

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TABLE 1

Rotatory power of ethanolamino-camphor-β-sulphonates

Solvent	Water		Methyl alcohol		Ethyl alcohol		Chloroform		Pyridine	
Conc. in D- g./100 ml L-	0·9944 0·9972		0·9992 1·0000		0·9972 0·9992		0·9944 0·9964		1·0032 1·0000	
Proposed [α]	$\pm \dfrac{4\cdot444}{\lambda^2-0\cdot1205}$		$\pm \dfrac{7\cdot425}{\lambda^2-0\cdot1027}$		$\pm \dfrac{7\cdot791}{\lambda^2-0\cdot1037}$		$\pm \dfrac{6\cdot420}{\lambda^2-0\cdot1118}$		$\pm \dfrac{7\cdot933}{\lambda^2-0\cdot1084}$	
Calculated λ_o	0·3471		0·3204		0·3220		0·3343		0·3292	
Line λ	Obs. [α]$\lambda^{22°}$		Obs. [α]$\lambda^{23\cdot5°}$		Obs. [α]$\lambda^{22\cdot5°}$		Obs. [α]$^{22\cdot5°}\lambda$		Obs. [α]$\lambda^{22°}$	
	D-	L-	D-	L-	D-	L-	D-	L-	D-	L-
Hg 4358	+63·85°	−64·17°	+85·56°	−85·00°	+89·75°	−90·07°	+81·95°	−81·29°	+96·69°	−96·50°
Li 4603	49·27	49·13	68·55	68·50	72·20	72·05	63·85	64·23	77·25	76·50
Cd 4678	45·25	45·12	64·05	63·50	67·68	67·55	59·83	60·21	71·77	72·00
Cd 4800	40·72	40·61	58·04	58·00	62·07	61·54	54·30	54·19	65·29	65·50
Cd 5086	32·18	32·08	47·53	47·50	50·14	50·54	43·74	44·15	52·83	53·00
Hg 5461	25·14	25·07	38·03	38·00	40·11	40·03	34·69	34·12	41·86	42·00
Hg 5780	20·61	21·05	32·02	32·00	34·09	34·02	28·66	29·10	35·48	35·00
Na 5893	19·60	19·55	30·52	30·50	32·08	32·02	27·15	27·09	33·39	33·50
Li 6104	17·59	17·54	27·52	27·50	29·08	29·02	24·63	24·58	29·90	30·00
Ne 6402	15·58	15·54	24·51	24·50	25·57	25·52	21·62	21·50	26·41	26·50
Cd 6438	15·08	15·04	24·01	24·00	25·07	25·02	21·11	21·07	25·91	26·00
Li 6708	13·57	13·53	21·51	21·50	22·56	22·51	19·10	19·06	23·42	23·50

DISCUSSION

The authors have previously described the rotatory power of ammonium camphor-β-sulphonate[4] and ethylamino camphor-β-sulphonate[5]. All these compounds exhibit simple rotatory dispersion in aqueous and non-aqueous solvents. In Table 2 is compared the rotatory power of these compounds in aqueous and non-aqueous solvents. The values of rotation constant are given in brackets.

TABLE 2

Comparison of rotatory power of some camphor-β-sulphonates

| Compound | $[\alpha]_{5461}$ in solvent | | | | |
R = $C_{10}H_{15}OSO_3H$	Water	Et. OH	Me. OH	Chloroform	Pyridine
R.NH$_3$	+27·14°	+49·00°	+43·51°	–	–
	(4·661)	(9·148)	(8·280)	–	–
R.NH$_2$CH$_2$CH$_3$	22·52	43·29	40·82	+45·50°	+44·31°
	(3·930)	(8·713)	(8·177)	(8 976)	(8·970)
R.NH$_2$CH$_2$CH$_2$OH	25·14	40·11	38·03	34·69	41·86
	(4·444)	(7·791)	(7·425)	(6·420)	(7·933)

From Table 2 it is clear that in water, methyl alcohol and ethyl alcohol ethylamino camphor-β-sulphonate exhibits a lower rotation as compared with ammonium-camphor-β-sulphonate. If we compare the rotatory power of ethylamino-camphor-β-sulphonate with ethanolamino-comphor-β-sulphonate we find that the latter has lower rotation in methyl alcohol, ethyl alcohol, chloroform and pyridine but has a higher rotation in water. Similar results are observed if a comparison is made for the values of rotation constant given in brackets. Thus it is seen that in non-aqueous solvents the effect of substuting the electropositive hydrogen by the electronegative alkyl group is to cause a decrease in rotatory power, further, the decrease gets more marked if another electronegative group hydroxyl is introduced in the alkyl group. The anomalous effect of introduction of hydroxyl group in ethylamino comphor-β-sulphonate in water solution is probably due to different degrees of ionization of these salts in water at the same concentration[6]. These results are in accordance with the general rule suggested by Rule[7] and Singh[8]. The electrical character of the groups is more marked in non-aqueous solvents.

The magnitude of rotatory power in polar and non-polar solvents is different[9]. The order of rotatory power in different solvents for different substances is different. Whereas for ammonium-camphor-β-sulphonate the rotatory power decreases in the order ethyl alcohol> methyl alcohol > water, for ethylamino-camphor-β-sulphonate the rotatory power decreases in the order chloroform>pyridine> ethyl alcohol >methyl alcohol >water but in the case of ethanolamino-camphor-β-sulphonate the arder of decreasing rotatory power in different solvents is pyridine > ethyl alcohol >methyl alcohol >chloroform >water. In the case of ammonium-

camphor-β-sulphonate and ethylamino-camphor-β-sulphonate the sequence of dielectric constants of the solvents follows the same order as that of rotatory power but in opposite sense. In the case of ethanolamino-camphor-β-sulphonate the sequence of rotatory power in different solvents does not seem to be related to their dielectric constant.

The magnitude of optical rotatory power of the D- and L- ethanolamino-camphor-β-sulphonate studied in this paper support Pasteur's principle of Molecular Dissymmetry. In 120 observations for twelve wavelengths the differences between D- and L- forms are well within experimental error.

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ROTATORY DISPERSION OF D- AND L- iso-PROPYLAMINO CAMPHOR-β-SULPHONATE

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ABSTRACT

Isopropylamine salts of D- and L- camphor-β-sulphonic acid have been prepared and characterised. Their rotatory power has been studied in water, methyl alcohol, ethyl alcohol, chloroform and pyridine. In each solvent they exhibit a simple rotatory dispersion in the visible region. The influence of alkyl groups, solvent and wavelength of light on optical rotatory power has been discussed.

INTRODUCTION

In previous communications the authors have described the rotatory dispersion of ammonium[1]-, dimethylamino[2]- and ethylamino[3]- camphor-β-sulphonates. In this paper the rotatory dispersion of iso-propylamine salt of active camphor-β-sulphonic acid is described. The influence of alkyl groups, solvent and wavelength of light on optical rotatory power in derivatives of D- and L- camphor-β-sulphonic acid has also been discussed.

EXPERIMENTAL

The D- and L- camphor-β-sulphonic acids were obtained by methods described earlier[3].

Isopropylamino-camphor-β-sulphonates :—

6·96 g. of D- or L- comphor-β-sulphonic acid was condensed with 1·77 g. of iso-propylamine in ethyl acetate. The product thus obtained was recrystallised from a mixture of benzene and alcohol. For D-salt: Yield 8 g., m. p. 134-36°; S = 10·78%, $C_{10}H_{15}OSO_3H.H_2N.CH(CH_3)_2$ requires S = 10·99%. For L-salt: Yield 8·2 g., m. p. 134–36°; S = 10·86%, $C_{10}H_{15}OSO_3H.H_2N.CH(CH_3)_2$ requires S= 10·99%.

The salts are white crystalline solid. They are highly soluble in water, methyl alcohol, ethyl alcohol and chloroform, less so in pyridine, and sparingly soluble in ethylacetate, carbon tetrachloride, benzene, ether and petroleum ether.

Using appioximately similar concentrations and temperatures for each isomer the rotatory power measurements were carried out in a 2 dcm. tube in different solvents. The results are recorded in Table 1. No change in rotatory power was observed even after twenty four hours.

The specific rotations for different wavelengths were analysed according to usual methods[4]. It was found that in each case the rotatory dispersion is simple and can be expressed by Drude's one term equation. The proposed equations are also given in Table 1.

[364]

TABLE 1

Rotatory power of *iso*-propylamino-camphor-β-sulphonate

Solvent	Water		Methyl alcohol		Ethyl alcohol		Chloroform		Pyridine	
Conc. in g./100ml D-	0·9580		0·9880		0·9983		1·0000		1·0048	
L-	0·9876		0·9932		0·0008		0·9920		0·9976	
Line λ	Obs. $[\alpha]_\lambda^{21}$		Obs. $[\alpha]_\lambda^{21}$		Obs. $[\alpha]_\lambda^{21}$		Obs. $[\alpha]_\lambda^{21}$		Obs. $[\alpha]_\lambda^{21}$	
Proposed $|\alpha|=$	$\pm\dfrac{3\cdot729}{\lambda^2-0\cdot1358}$		$\pm\dfrac{8\cdot055}{\lambda^2-0\cdot1034}$		$\pm\dfrac{8\cdot307}{\lambda^2-0\cdot1067}$		$\pm\dfrac{8\cdot852}{\lambda^2-0\cdot1056}$		$\pm\dfrac{7\cdot945}{\lambda^2-0\cdot0972}$	
Calculated $\lambda_0=$	0·3685		0·3215		0·3266		0·3249		0·3117	
	D-	L-	D-	L-	D-	L-	D-	L-	D-	L-
Hg4358	+68·89°	−68·85°	+93·11°	−93·13°	+99·61°	−99·99°	+106·00°	−105·84	+86·58°	−86·29°
Li4603	49·06	49·10	74·39	74·50	79·09	78·93	83·00	83·16	69·66	69·64
Cd4678	44·88	45·05	69·33	69·47	74·08	73·94	78·00	78·12	65·68	65·09
Cd4800	39·66	39·49	64·27	63·43	67·08	67·43	71·00	71·06	59·71	59·54
Cd5086	30·79	30·37	51·61	51·85	55·06	54·95	58·00	57·96	49·26	49·45
Hg5461	22·96	22·78	41·49	41·28	43·05	43·46	46·00	45·86	39·80	39·36
Hg5780	18·78	18·73	34·91	34·73	36·54	36·47	38·50	38·81	33·34	33·30
Na5893	17·74	17·71	32·88	33·22	34·54	34·47	36·50	36·79	31·84	31·79
Li6104	15·65	15·69	29·85	29·70	31·03	30·97	33·00	33·25	28·86	28·76
Ne6402	13·56	13·66	26·31	26·17	27·53	27·47	29·00	29·23	25·37	25·23
Cd6438	13·04	13·16	25·80	25·67	27·03	26·97	28·50	28·72	24·88	24·72
Li6708	12·00	12·15	23·27	23·15	24·02	23·98	25·50	25·70	22·39	22·70

DISCUSSION

The Effect of Alkyl Group on Rotatory Power :—

The ammonium-[1], methylamino[5], dimethylamino-[2], ethylamino-[3] and *iso*-propylamino- camphor - β - sulphonates exhibit 'simple' rotatory dispersion as the rotatory power of these compounds can be expressed by Drude's one term equation,

$\alpha = \dfrac{K}{\lambda^2 - \lambda^2_o}$, where K is the rotation constant and λ_o the dispersion constant. In Table 2 is compared the rotatory power of these compounds. The values of rotation constant, K, have also been given in brackets below the specific rotation for Hg_{5461}.

TABLE 2

Comparison of rotatory power

Formula	Sp. rotation for Hg_{5461} in solvent				
R = $C_{10}H_{15}OSO_3H$	Water	Me.OH	Et.OH	$CHCl_3$	C_5H_5N
R. NH_3	+27·14° (4·661)	+43·51° (8·280)	+49·00° (9·148)	—	—
R. NH_2CH_3	24·0 (3·891)	42·0 (7·626)	42·5 (7·664)	+45·5° (8·202)	+40·5° (7·493)
R. NH. $(CH_3)_2$	22·05 (3·615)	31·01 (5·342)	38·27 (7·170)	44·49 (8·492)	52·68 (10·29)
R. $NH_2CH_2CH_3$	22·52 (3·930)	40·82 (8·177)	43·29 (8·713)	45·50 (8·976)	44·31 (8·970)
R. $NH_2CH(CH_3)_2$	22·96 (3·729)	41·49 (8·055)	43·05 (8·307)	46·00 (8·852)	39·80 (7·945)

In we compare the rotatory power of ammonium-comphor-β-sulphonate with that of methylamino-, dimethylamino-, ethylamino or *iso*-propyl-amino-camphor-β-sulphonate in water, methyl alcohol and ethyl alcohol we find that the effect of substituting the electronegative alkyl group in place of electropositive hydrogen is to cause a decrease in rotatory power. Ethyl group is more electronegative than methyl and we find that if methyl is substituted by ethyl, as in case of methylamino- and ethylamino-camphor-β-sulphonates, a decrease in rotatory power is observed in water and methyl alcohol but a slight increase is observed in ethyl alcohol and pyridine. The difference between the electronegativity of methyl and ethyl is not clearly marked. Similarly the difference between ethyl and *iso*-propyl group is also not distinct. The alkyl groups methyl, ethyl and *iso*-propyl differ in their electronegativity only to a slight extent. The observed rotatory power in polar solvents is known to be effected by interaction between the polar groups and the solvent. This is in all probability the explanation of slight irregularities observed here. As pointed out earlier the effect of the electronegative group is generally to cause a decrease in rotatory power[6]. The results observed in the present studies also generally support this view.

Effect of solvent on Rotatory Power :—

The effect of solvent on rotatory power of the compounds mentioned in Table 2 is given in Table 3 below.

TABLE 3

Effect of Solvent on Rotatory Power

Compound: Camphor-β-sulphonate of	Order of rotatory power in solvents
Ammonia	Et.OH > Me.OH > H_2O
Methylamine	$CHCl_3$ > Et.OH > Me.OH > C_5H_5N > H_2O
Dimethylamine	C_5H_5N > $CHCl_3$ > Et.OH > Me.OH > H_2O
Ethylamine	$CHCl_3$ > C_5H_5N > Et.OH > Me.OH > H_2O
Iso-propylamine	$CHCl_3$ > Et.OH > Me.OH > C_5H_5N > H_2O

The dielectric constant of these solvents in the decreasing order is water (80) > methyl alcohol (34·7) > ethyl alcohol (25·72) > pyridine (12·42) > Chloroform (5·06). We find from Table 3 that generally the higher the dielectric constant of the solvent, the lower is the rotation observed in that solvent. Pyridine is a basic solvent and it is therefore not surprising that it shows anomalous behaviour in the case of these substances which are salts of strong acid and strong bases and as such have a strong tendency to ionise. In may also be pointed out here that it would be more appropriate to compare the dielectric constants of the solutions instead of the dielectric constants of the solvents.

Physical Identity of Enantiomers :—

The magnitudes of optical rotatory power of **D-** and **L-** *iso*-propylamino-camphor-β-sulphonates studied in this paper support Pasteur's principle of Molecular Dissymmetry. In 120 observations for twelve wavelengths the differences between the D- and L- form are well within experimental error.

ACKNOWLEDGEMENT

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EFFECT OF LENGTHENING ALKYL CHAIN ON THE OPTICAL ROTATORY POWER IN AMINO DERIVATIVES OF ACTIVE CAMPHOR-β-SULPHONIC ACID

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ABSTRACT

n-Amylamine salts of D- and L-camphor β-sulphonic acid have been prepared and characterised. Their rotatory dispersion has been studied in water, methyl alcohol, ethyl alcohol, chloroform and pyridine. A comparison of their rotatory power with ammonium-, methylamino- ethylamino-and *iso*-propylamino-D- or L-camphor-β-sulphonate has been made.

INTRODUCTION

The authors have previously studied ammonium-[1], ethylamino-[2], dimethyl-amino-[3] and *iso*-propylamino- [4] D - and L-camphor-β-sulphonates. Siingh and Amma had studied methylamino-camphor-β-sulphonate[5]. In this paper the authors have prepared and described the rotatory power of *n*-amylamino-camphor-β-sulphonate. The effect of lengthening alkyl chain on the optical rotatory power in amino derivatives of active camphor-β-sulphonic acids has been discussed.

EXPERIMENTAL

D- and L-camphor-β-sulphonic acids were prepared in the manner described by the authors earlier[2].

n-Amylamino-camphor-β-sulphonate :—

4·3 g. of D- or L- camphor-β-sulphonic acid was condensed with 1·61 g. *n*-amylamine in ethyl acetate medium. The product thus obtained was recrystallised from benzene. Found: for D-salt-yield 4·5 g., m. p. 133-35°, S = 9·86%; for L-salt-yield 4·8 g., m. p. 133-35°, S=9·98%; $C_{10}H_{15}OSO_3H.H_2N.C_5H_{11}$ requires S= 10·03%.

The salts are white crystalline substances. They are highly soluble in water, methyl alcohol, ethyl alcohol, chloroform and pyridine but less so in ethyl acetate, carbon tetrachloride, benzene, acetone, ether and petroleum ether.

The rotatory power measurements were carried out in a 2 dcm. tube in different solvents. For the sake of comparison approximately similar concentrations were used (about 1 %) as used by the authors earlier[1,2,3,4]. In twenty four hours no appreciable change in rotatory power was observed. The observations are recorded in Table 1. The table also gives the proposed dispersion equations obtained by mathematical analysis of the data.

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TABLE 1

Rotatory power of n-amylamino-camphor-β-sulphonate

Solvent	Water		Methyl alcohol		Ethyl alcohol		Chloroform		Pyridine	
Conc. in g./100 ml D-	0·9824		0·9816		1·0000		1·0000		1·0000	
Conc. in g./100 ml L-	0·9964		0·9976		0·9996		0·9984		0·9968	
Proposed [α]=	$\pm\dfrac{2\cdot933}{\lambda^2-0\cdot1415}$		$\pm\dfrac{7\cdot337}{\lambda^2-0\cdot0987}$		$\pm\dfrac{7\cdot411}{\lambda^2-0\cdot1057}$		$\pm\dfrac{9\cdot593}{\lambda^2-0\cdot0895}$		$\pm\dfrac{8\cdot913}{\lambda^2-0\cdot0932}$	
Calculated $\lambda_0=$	0·3761		0·3141		0·3251		0·2991		0·3052	
Line λ	Obs. 22·5° $[\alpha]_\lambda$		Obs. 22·5° $[\alpha]_\lambda$		Obs. 22° $[\alpha]_\lambda$		Obs. 22° $[\alpha]_\lambda$		Obs. 21·5° $[\alpha]_\lambda$	
	D-	L-	D-	L-	D-	L-	D-	L-	D-	L-
Hg4358	+60·05°	−60·21°	+79·46°	−79·69°	+88·50°	−88·03°	+96·00°	−95·65°	+92·00°	−92·29°
Li4603	41·73	41·64	64·69	64·65	70·00	70·02	78·50	78·62	75·50	75·24
Cd4678	37·66	37·63	60·61	60·64	65·50	65·52	74·50	74·11	71·00	70·72
Cd4800	33·02	33·11	55·52	55·63	59·50	59·52	68·50	68·10	65·00	65·20
Cd5086	25·44	25·09	45·84	46·11	49·00	48·51	57·00	56·59	54·00	53·67
Hg5461	18·83	18·56	36·67	36·58	38·50	38·51	46·00	46·07	43·50	43·63
Hg5780	15·26	15·05	31·07	31·07	32·50	32·51	39·00	39·06	37·00	37·11
Na5893	14·25	14·05	29·54	29·57	31·00	30·51	37·50	37·05	35·00	35·11
Li6104	12·72	12·54	26·99	27·06	28·00	28·01	34·00	34·05	32·00	31·60
Ne6402	11·19	11·03	23·94	23·55	24·50	24·50	30·00	30·04	28·00	28·08
Cd6438	10·66	10·53	23·43	23·05	24·00	24·00	29·50	29·54	27·50	27·58
Li6708	9·67	9·53	20·88	21·05	21·50	21·50	26·50	26·54	25·00	25·08

DISCUSSION

Earlier work on the effect of lenghtening alkyl chain attached to an optically active residue has been reviewed in a comprehensive manner by Frankland[6]. The results obtained in the case of menthyl esters of aliphatic acids, esters of active amyl alcohol[7], esters of carvoxime[8] or a series of active secondary alcohols[9] showed that there does not appear to be any simple relationship between rotatory power and the effect of lengthening alkyl chain. In Table 2 are given the values of some derivatives of active camphor-β-sulphonic acid.

TABLE 2

Comparison of rotatory power of some derivatives of active
camphor-β-sulphonic acid

Formula $\quad CH_2SO_3H$ $\quad\mid$ $CH_2——C————CO$ $\mid\quad\mid\quad\mid$ $R=\mid CH_3—C—CH_3\mid$ $\mid\quad\mid\quad\mid$ $CH_2——CH————CH_2$	Molecular rotation (M/100) for Hg_{5461}[+]				
	Water	Me.OH	Et.OH	CHCl$_3$	C$_5$H$_5$N
R.NH$_3$	+67·57°	+108·3°	+122·0°	—	—
R.NH$_2$CH$_3$	63·13	110·5	111·8	+119·7°	+105·3°
R.NH$_2$CH$_2$CH$_3$	62·38	113·1	119·9	126·0	122·7
R.NH.(CH$_3$)$_2$	61·08	85·90	106·0	123·2	146·0
R.NH$_2$.CH.(CH$_3$)$_2$	66·82	120·7	125·3	133·9	115·8
R.NH$_2$.CH$_2$.CH$_2$.CH$_2$.CH$_2$CH$_3$	60·08	116·9	122·8	146·8	138·8

+ Calculated values from earlier data and also from Table 1

(See ref. 1,2,3,4,5)

From Table 2 it is obvious that no rule can be derived for the effect of lengthening alkyl chain in amino derivatives of active camphor-β-sulphonic acid. The change in rotatory power follows no regular pattern. If we compare the values of ethyl amine and dimethylamine salts of active camphor-β-sulphonic acid, we find that the compound containing branched chain has a smaller rotatory power in water, methyl alcohol, ethyl alcohol and chloroform but a reverse effect in obtained in the basic solvent pyridine. The results of the authors indicate that in the case of amino derivatives of active camphor-β-sulphonic acid also there does not appear to be any simple relationship between rotatory power and the effect of lengthening alkyl chain.

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It may also be mentioned that in the case of n amylamino-camphor-β-sulphonate studied in this paper the order of decreasing rotatory power in different solvents is chloroform > ethyl alcohol > methyl alcohol > pyridine > water. This order is opposite to that of the dielectric constant of these solvents if we neglect pyridine. Anomalous results in case of pyridine have also been obtained by us earlier[4]. n-Amylamino-comphor-β-sulphonate is a salt of fairly strong amine and a strong monobasic acid. It has a strong tendency to ionise and anomalous behaviour in the case of the basic solvent pyridine is not very surprising.

In about 120 observations of rotatory power of D-and L- n-amylamino-camphor-β-sulphonate studied in the this paper the differences in the magnitude of rotatory power of optical antipodes are well within the limits of experimental error and thus further support Pasteur's principle of molecular asymmetry.

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SELF-RECIPROCAL FUNCTIONS INVOLVING HYPERGEOMETRIC FUNCTIONS

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1. A function is said to be self-reciprocal in the Hankel transform of order v, if it satisfies the integral equation

$$f(x) = \int_0^\infty (xy)^{\frac{1}{2}} J_v (xy) f(y)\, dy, \ (v > -1) \tag{1.1}$$

We shall denote as usual by R_v, those functions that satisfy (1.1). For $R_{\frac{1}{2}}$ and $R_{-\frac{1}{2}}$ we shall write R_s and R_c respectively. A number of functions $P(x)$, known as kernels which transform a given R_μ function $f(x)$ into an R_v function $g(x)$, and *vice versa*, by means of the equation

$$g(x) = \int_0^\infty P(xy) f(y)\, dy$$

has been given by several authors.

The object of this note is to use the following kernels given by B. Mohan (6) in investigating certain new self-reciprocal functions.

(1) $x^{3/2-v} J_{v-1/2}(1/2\ x) J_{v-3/2}(1/2\ x)$ transforms R_{3v-3} into R_v and *vice versa*

(2) $x^{1/2-v} J_{v-1/2}(1/2\ x) J_{v-1/2}(1/2\ x)$ transforms R_{3v-1} into R_v and *vice versa*

(3) $J_{v/2-1/4}(1/2\ x) J_{1/4-v/2}(1/2\ x)$ transform R_{1-v} into R_v and *vice versa*

(4) $x^{v/2+1} K_{1/2(v-1)}(x)$ transforms R_1 into R_v and *vice versa*

We shall apply the first three kernels to the R_v function given by Howell (2)

$$x^{v+2n+1/2}\ e^{-1/2\ x^2} \left| \begin{matrix} n+v \\ -n \end{matrix} \right. (1/2\ x^2)$$

$$= \frac{(-)^n}{n!}\ 2^{\frac{1}{2}(n+v+1)}\ x^{n-\frac{1}{2}}\ e^{-\frac{1}{4}x^2}\ W_{3n/2+v/2+1/2,\ n/2+v/2}(\tfrac{1}{2}\ x^2) \tag{1.2}$$

where n is a $+ve$ integer. It is interesting to find however that the functions obtained thus are in the form of a generalised hypergeometric function $_3F_3$. The last of the kernels given above is applied to the R_1 Function

$$x^{-\frac{1}{2}}\ _2F_3 (\tfrac{1}{2}+\tfrac{1}{2}\mu+\tfrac{1}{2}v,\ 1+\tfrac{1}{2}\mu+\tfrac{1}{2}v\ ;\ 1+\mu,\ 1+v,\ \mu+v+1\ ;\ -x^2) \tag{1.3}$$

$R(\mu) > -1$, $R(v) > -1$ given by V. V. L. N. Rao (7) and the resulting R_v function comes out in the form of a generalised hypergeometric function $_4F_3$.

2. Before applying the first three kernels to the R_ν function (1·2) let us evaluate the general integral

$$I = \int_0^\infty J_\mu \left(\tfrac{1}{2} xy\right) J_\nu \left(\tfrac{1}{2} xy\right) \left(\tfrac{1}{4} xy\right)^\lambda y^{n-\frac{1}{2}} e^{-\frac{1}{4} y^2} W_{3n/2+\alpha/2+1/2,\, n/2+\alpha/2} \left(\tfrac{1}{2} y^2\right) dy,$$

It is known that

$$J_\mu (x)\, J_\nu (x) = \frac{\left(\tfrac{1}{2} x\right)^{\mu+\nu}}{\Gamma(\mu+1)\, \Gamma(\nu+1)}\; {}_2F_3 \left\{ \begin{array}{c} \frac{\mu+\nu+1}{2}, \frac{\mu+\nu+2}{2} \\ \mu+1,\, \nu+1,\, \mu+\nu+1 \end{array} ; -x^2 \right\}$$

on using the following integral due to Goldstein (1),

$$\int_0^\infty x^{l-1} e^{-\frac{1}{2} x} W_{k,m}(x)\, dx = \frac{\Gamma\left(l+m+\tfrac{1}{2}\right)\, \Gamma\left(l-m+\tfrac{1}{2}\right)}{\Gamma(l-k+1)},$$

where $R\left(l \pm m + \tfrac{1}{2}\right) > 0$,

we get

$$I = \int_0^\infty \left[\sum_{r=0}^\infty \frac{(-1)^r\, \Gamma(\mu+\nu+2r+1)\, \left(\tfrac{1}{4} xy\right)^{\lambda+\mu+\nu+2r}}{r!\, 1\, (\mu+r+1,\, \Gamma(\nu+r+1)\, \Gamma(\mu+\nu+r+1)} \right] \times$$

$$\times\, y^{n-\frac{1}{2}} e^{-\frac{1}{4} y^2} W_{3n/2+\alpha/2+1/2,\, n/2+\alpha/2} \left(\tfrac{1}{2} y^2\right) dy, \qquad (2·1)$$

$$= \sum_{r=0}^\infty \left\{ \int_0^\infty \frac{(-1)^r\, \Gamma(\mu+\nu+2r+1)\, \left(\frac{x}{2\sqrt{2}}\right)^{\lambda+\mu+\nu+2r}}{r!\, \Gamma(\mu+r+1)\, \Gamma(\nu+r+1)\, \Gamma(\mu+\nu+r+1)} \left(\frac{1}{\sqrt{2}}\right)^{3/2-n} \times \right.$$

$$\left. \times\, t^{\frac{\lambda+\mu+\nu+n}{2}+r-\frac{3}{4}} e^{-t/2} W_{3n/2+\alpha/2+1/2,\, n/2+\alpha/2} (t)\, dt \right\} \qquad (2·2)$$

$$= \sum_{r=0}^\infty \left[\frac{(-1)^r\, \Gamma(\mu+\nu+2r+1)\, \Gamma\left\{\tfrac{1}{2}(\mu+\nu+\lambda+\alpha)+n+r+\tfrac{3}{4}\right\}\, \Gamma\left\{\tfrac{1}{2}(\lambda+\mu+\nu-\alpha)+r+\tfrac{3}{4}\right\}}{r!\, \Gamma(\mu+r+1)\, \Gamma(\nu+r+1)\, \Gamma(\mu+\nu+r+1)\, \Gamma\left\{\tfrac{1}{2}(\mu+\nu+\lambda-\alpha)+r+\tfrac{3}{4}-n\right\}} \right.$$

$$\qquad (2·3)$$

$$\left. \times\, 2^{n/2-\frac{3}{4}} \left(\frac{x}{2\sqrt{2}}\right)^{\lambda+\mu+\nu+2r} \right],$$

$$= \frac{\Gamma\left[\tfrac{1}{2}(\lambda+\mu+\nu+\alpha)+n+\tfrac{3}{4}\right]\, \Gamma\left\{\tfrac{1}{2}(\lambda+\mu+\nu-\alpha)+\tfrac{3}{4}\right\}}{2^{3/4-n/2}\, \Gamma(\mu+1)\, \Gamma(\nu+1)\, \Gamma\left\{\tfrac{1}{2}(\mu+\nu+\lambda-\alpha)+\tfrac{3}{4}-n\right\}} \left(\frac{x}{2\sqrt{2}}\right)^{\lambda+\mu+\nu} \times$$

$$\times\, {}_4F_4 \left\{ \begin{array}{c} \frac{\mu+\nu+1}{2}, \frac{\mu+\nu+2}{2}, \frac{\lambda+\mu+\nu+\alpha+2n+\frac{3}{2}}{2}, \frac{\mu+\lambda+\nu-\alpha+\frac{3}{2}}{2} \\ \mu+1,\, \nu+1,\, \mu+\nu+1,\, \frac{\mu+\lambda+\nu+\frac{3}{2}-2n-\alpha}{2} \end{array} ; -\frac{x^2}{2} \right\} \qquad (2·4)$$

provided that $R\left(\lambda+\mu+\nu+\alpha+2n+3/2\right) > 0$ and $R\left(\lambda+\mu+\nu-\alpha+\tfrac{3}{2}\right) > 0$.

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The term by term integration involved in the above integral I is justified because

(i) $y^{-\mu-\nu} J_\mu (\tfrac{1}{2} xy) J_\nu (\tfrac{1}{2} xy)$ represents an integral function and is consequently uniformly convergent in any arbitrary interval $(0, \xi)$, and

(ii) The integral

$$\int_0^\infty \left| \sum_{r=0}^\infty \frac{\Gamma(\mu+\nu+2r+1) (\tfrac{1}{2} xy)^{\lambda+\mu+\nu+2r}}{r! \, \Gamma(\mu+r+1) \, \Gamma(\nu+r+1) \, \Gamma(\mu+\nu+r+1)} \right.$$

$$\left. y^{n-\frac{1}{2}} \, e^{-\frac{1}{4} y^2} \, W_{3n/2+\alpha/2+1/2, \, n/2+\alpha/2} \, (\tfrac{1}{2} y^2) \right| \, dy$$

coverges under the stated conditions on account of the asymptotic behaviour

$$W_{k, \, m} (z) \sim 0 \, (z^k \, e^{-\frac{1}{2}z})$$

3. Now we shall use the above integral (2·4) in finding certain new self-reciprocal functions.

Applying the first kernel to the R_ν function (1·2), we get the $R_{3\nu-3}$ function

$$g(x) = \int_0^\infty (xy)^{\frac{3}{2}-\nu} J_{\nu-1/2} (\tfrac{1}{2} xy) J_{\nu-\frac{3}{2}} (\tfrac{1}{2} xy) y^{n-\frac{1}{2}} \, e^{-\frac{1}{4} y^2}$$

$$W_{3n/2+\nu/2+1/2, \, n/2+\nu/2} \, (\tfrac{1}{2} y^2) \, dy.$$

By putting $\tfrac{3}{2}-\nu$, $\nu-\tfrac{1}{2}$, $\nu-$, and ν for λ, μ, ν, and α respectively in (2·4), we easily see that the above function reduces (after replacing $3\nu-3$ by μ in the resulting function) to the R_μ function

$$g(x) = x^{\mu/3+1/2} \, {}_3F_3 (\mu/3+1, \, \mu/3+n+3/2, \, 1/2; \, \mu/3+3/2, \, 2\mu/3+1, \, 1/2-n; \, -x^2/2)$$

for $\mu - 6n > -\tfrac{3}{2}$.

Particular case: When $n=0$, we find that the

function $x^{\mu/3+1/2} \, {}_1F_1 (\mu/3+1; \, 2\mu/3+1; \, -x^2/2)$ is R_μ for $\mu > -1$

Applying Kummer's transformation formula

$${}_1F_1 (\alpha; \, \rho; \, z) = e^z \, {}_1F_1 (\rho-\alpha; \, \rho; \, -z)$$

to this function we get

$$x^{\mu/3+\frac{1}{2}} \, e^{-\frac{1}{2} x^2} \, {}_1F_1 (\mu/3; \, 2\mu/3+1; \, \tfrac{1}{2} x^2)$$

which is R_μ for $\mu > -1$.

$\mu=0$ obviously reduces the above function to the well known R_0 function $x^{\frac{1}{2}} \, e^{-\frac{1}{2}x^2}$.

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Now using the first kernel with the function (1·2) with v replaced by $3v - 3$, and after a similar analysis as above, we get the R_v function

$$g(x) = x^{v-\frac{1}{2}}\ {}_3F_3\left(v,\ 2v+n-1,\ 2-v\ ;\ v+\tfrac{1}{2},\ 2v-1,\ 2-v-n\ ;\ -x^2/2\right)$$

for $v > \tfrac{1}{2} - n$

Particular cases : (i) when $n = 0$,

$$g(x) = x^{v-\frac{1}{2}}\ {}_1F_1\left(v\ ;\ v+\tfrac{1}{2}\ ;\ -\tfrac{1}{2}x^2\right)$$

which is R_v for $v > \tfrac{1}{2}$,

So that the function $x^{v-}\ e^{-\frac{1}{2}x^2}\ {}_1F_1\left(\tfrac{1}{2}\ ;\ v+\tfrac{1}{2}\ ;\ \tfrac{1}{2}x^2\right)$

is R_v for $v > \tfrac{1}{2}$,

a function otherwise obtained by B. Mohan (4).

(ii) B. Mohan (3) has shown that the function

$$x^{v+2n+\frac{1}{2}}\ e^{-\frac{1}{2}x^2}\ {}_1F_1\left(-n;\ n+v+1;\ x^2/2\right)$$

is R_v for $v + 2n > -1$.

Putting $n = -\tfrac{1}{2}$, we see that this function reduces to $x^{v-\frac{1}{2}}\ e^{-\frac{1}{2}x^2}\ {}_1F_1\left(\tfrac{1}{2}\ ;\ v+\tfrac{1}{2}\ ;\ \tfrac{1}{2}x^2\right)$ which is the same as the function given in (i)

4. The second kernel when applied to the R_v function (1.2) yields the R_{3v-1} function

$$g(x) = \int_0^\infty (xy)^{\frac{1}{2}-v}\ J_{v-\frac{1}{2}}\left(\tfrac{1}{2}xy\right) J_{v-\frac{1}{2}}\left(\tfrac{1}{2}xy\right) y^{n-\frac{1}{2}}\ e^{-\frac{1}{4}y^2}\ W_{3n/2+v/2+1/2,\ n/2+v/2}\left(\tfrac{1}{2}y^2\right)\ dy.$$

Putting $\tfrac{1}{2}-v,\ v-\tfrac{1}{2},\ v-\tfrac{1}{2}$, and v for $\lambda,\ \mu,\ v$ and α respectively in (2·4), we find that the above function reduces (after replacing $3v-1$ by λ in the resulting function) to the R_λ function

$$g(x) = x^{\lambda/3-1/6}\ {}_3F_3\left(\lambda/3+1/3,\ n+\lambda/3+5/6,\ 1/2\ ;\ \lambda/3+5/6,\ 2\lambda/3+2/3,\right.$$
$$\left. 1/2-n\ ;\ -x^2/2\right)$$

where $\lambda > -6n - 5/2$.

Particular case : when $n = 0$, we find that the function $x^{\lambda/3-1/6}\ {}_1F_1\left(\lambda/3+1/3\ ;\ 2\lambda/3+2/3\ ;\ -\tfrac{1}{2}x^2\right)$ is R_λ for $\lambda > -1$

For $\lambda = 2$ we get the R_2 function

$$x^{\frac{1}{3}}\ {}_1F_1\left(1\ ;\ 2\ ;\ -\tfrac{1}{2}x^2\right)$$

This results as an immediate consequence of the fact that the function

$$x^{1/2-1/2\,v}\ f_{v/2}\left(x\sqrt{2}\right)\ \text{is}\ R_v,$$

where $f_v(x) = \dfrac{(1/2\,x)^v}{\Gamma(v+1)}\ {}_1F_1\left(1\ ;\ v+1\ ;\ -1/4\,x^2\right)$,

a result given by B. Mohan (5)

Again, applying the second kernel to the function (1·2) with ν replaced by $3\nu - 1$, we get, after a similar analysis, the R_ν function

$$g'(x) = x^{\nu - \frac{1}{2}} \, {}_3F_3 \left(\nu, 2\nu + n, 1 - \nu \; ; \; \nu + \tfrac{1}{2}, \; 2\nu, \; 1 - \nu - n \; ; \; -x^2/2 \right)$$

valid for $\nu + n > 0$.

Particular case : Putting $n = 0$, we find that the function

$$g(x) = x^{\nu - \frac{1}{2}} \, {}_1F_1 \left(\nu \; ; \; \nu + \tfrac{1}{2} \; ; \; -\tfrac{1}{2} x^2 \right)$$

$$= x^{\nu - \frac{1}{2}} \, e^{-\frac{1}{2} x^2} \, {}_1F_1 \left(\tfrac{1}{2} \; ; \; \nu + \tfrac{1}{2} \; ; \; \tfrac{1}{2} x^2 \right),$$

which is R_ν for $\nu > 0$,

a result (already referred to in the above) established by B. Mohan (4)

5. The third kernel when applied to the R_ν function (1.2), gives the $R_{1-\nu}$ function

$$\int_0^\infty J_{1/2\nu - 1/4} \, (1/2 \; xy) \, J_{1/4 - 1/2\nu} \, (1/2 \; xy) y^{n - \frac{1}{2}} \, e^{-1/4 \, y^2} \; W_{3n/2 + \nu/2 + 1/2, \; n/4 + \nu/2} \frac{(1/2 \; y^2) \; dy.}{}$$

Putting 0, $1/2\nu - 1/4$, $1/4 - 1/2\nu$, and ν for λ, μ, ν and α respectively in (2.4), we see that the above function yields (after replacing $1 - \nu$ by μ in the resulting function) the R_μ function

$$g(x) = {}_3F_3 \left(1/2, \; \mu/2 + 1/4, \; n + 5/4 - \mu/2 \; ; \; \mu/2 + 3/4, \; 5/4 - \mu/2, \; 1/4 + \mu/2 - n \; ; \; -x^2/2 \right)$$
$$\text{for } \mu < 4n + 5/2$$

Particular case : when $n = 0$

We find that the function

$${}_1F_1 \; 1/2 \; ; \; \mu/2 + 3/4 \; ; \; -1/2x^2 \text{ is } R_\mu \text{ for } \mu < 5/2$$

a result proved otherwise by B. Mohan (4). If however, we apply the 3rd kernel to the function (1·2) with ν replaced by $1 - \nu$, we get the same R_ν function given above.

6. The last kernel when applied to the R_1 function (1·3) yields the R_ν function

$$x^{\nu/2 + 1} \int_0^\infty y^{\nu/2 + 1/2} \; K_{1/2 \, (\nu - 1)} \, {}^{(xy)} \, {}_2F_3 \left(\mu/2 + \nu/2 + 1/2, \; \mu/2 + \nu/2 + 1 ; \; \mu + 1, \; \nu + 1, \right.$$
$$\left. \mu + \nu + 1 \; ; \; -y^2 \right) dy.$$

Evaluating this integral with the help of a result given by Miss Sinha
{ (8), p. 207 },

we find that the function

$$g(x) = x^{-\frac{1}{2}} \, {}_4F_3 \left(\mu/2 + \nu/2 + 1/2, \; \mu/2 + \nu/2 + 1, \; \nu/2 + 1/2, \; 1 \; ; \; \mu + 1, \; \nu + 1, \; \mu + \nu + 1 \; ; \; -4/x^2 \right)$$

is R_ν provided that $|x| > 2$ and $\nu > -1$.

[376]

I offer my thanks to Dr. Brij Mohan for his help and guidance in the preparation of this note.

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A COMPARATIVE STUDY OF HUMIC ACIDS SEPARATED FROM SOME BLACK SOILS OF INDIA

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ABSTRACT

A comparative study of humic acids of some black soils was carried out. Although there were differences in their parent materials but the formation of similar bands on the chromatograms of these acids seems to indicate that they are of similar nature and the formation of the organic matter of these soils might have been under somewhat similar conditions.

Kumada[4] (1955) carried out physico-chemical studies on the humic acids by taking absorption spectra in alkaline solution and also determined elemental composition of various humic acids. He found no essential differences in the absorption spectra of humic acids of different carbon contents and C/N ratios. Stevenson, Van Winkle and Martin[9] (1952) examined clay absorbed organic colloids by electrophoretic methods and found that they consisted principally of dark coloured humic acids with two additional colloids present in very small concentrations. Scheffer and his associates[7] (1955) investigated a number of humic acid preparations by paper electrophoresis method utilizing different field intensities and found no difference between artificial and natural humic acids. Singh[8] found a close similarity in the nature of the organic matter of typical black soils obtained from different parts of India. Kononova[2] (1956) worked on the humus of most important soil types of U. S. S. R. and found that humic acids from strongly podzolised soils and from Krasmogem are only slightly condensed. The least condensation occurred in the fulvic acids, all of which were condensed to a similar extent. X-ray analysis showed that humic and fulvic acids have the structural characteristics of carbonised substances. Kasatochkin and Berbrand[1] (1958) applied X-ray and infra-red spectroscopic techniques to the study of the structure and the nature of humic substances and their findings also supported the views of Kononova. Infra-red spectroscopy of humic and fulvic acids separated from Chernozems and podzols showed wide differences in their structures. Larina and Kasatochkin[6] (1957) also confirmed that humic acids obtained from different sources are built of aromatic carbon lattices with side chain carboxyl groups. Kononova and her associates[3] (1958) used chromatographic techniques in studying the nature of humic substances of soils and found that humic acid from a chernozem and humic and fulvic acids from asod-podzolised soils, consisted of three types of fractions, the relative proportions of which differ in different substances. The different type also fluoresce differently in ultra-violet light. Kumada and Aizawa[5] (1958) carried out the spectrum analysis of soil and artificial humic acids by KBr-disk method and indicated the presence of hydrogen bonded $-OH$, aromatic and aliphatic $-CH$ groups, $-COOH$, $C=C$ and various aliphatic and aromatic compounds including phenols, quinones and alcohols.

Considering the above diverse nature of humic acids separated from different soils, an attempt has been made here to study the nature of humic acids obtained from five black soils by paper chromatography.

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MATERIALS AND METHODS

Five black soils from different parts of India were taken for a comparative study. A general description of these soils is given in table 1.

TABLE 1

A general description of the black soils

Sample no.	locality	Depth in inches	Parent material	Colour
1.	Tutuwari (Ballia) U. P.	0-12	Gangetic Alluvium	Grey, Dark grey when moist
2.	Chanwar (Mirzapur) U. P.	0-10	-do-	Dark grey.
3.	Bheri (Shahabad) Bihar	0-12	-do-	Grey, Dark grey when moist
4.	Akola M. P.	0-6	Vindhyam hills mixed sand- stones	Dark brown
5.	Coimbatore Madras	0-12	Granite-alluvium	Very dark grey when moist

Organic carbon was determined by Walkley and Black[10] method and nitrogen was determined by semi-micro-Kjeldahl method for finding out the C/N ratios for comparison of different humic acids. The results obtained are given in the table No. 2.

TABLE 2

Showing the percentages of C & N and C/N ratios in different humic acids

Humic acid of	C%	N%	C/N ratio
Ballia soil	57·1	3·5	16·31
Mirzapur soil	56·5	3·4	16·61
Shahabad soil	56·4	3·3	17·09
Akola soil	55·2	3·8	14·53
Coimbatore soil	54·3	3·2	16·96

Separation of humic acid :

Various methods have been suggested to separate humic acid from soils, but none seems to be satisfactory in view of the fact that the material separated is not necessarily the same as originally present in the untreated soil. In many of these methods, the initial treatment of the soil with hydrochloric acid is avoided. In the

present study also, the soils were directly treated with sodium hydroxide and then with hydrochloric acid to precipitate the humic acid. The acid, even so obtained, would in all probability, be an artefact.

100 gm. sample of each soil was taken in 1 litre beaker and 500 cc. of 0 5N-NaOH solution was added. After thorough stirring, it was kept on a water bath and was heated for two hours and allowed to stand for 48 hours. The dark coloured liquid was removed and calculated amount of fresh alkali solution was added to the soil. The process was repeated till no coloured liquid was obtained. The filtrate and the washings were combined and treated with 10 per cent hydrochloric acid till complete precipitation was achieved. The precipitate was filtered and washed several times with 2 per cent hydrochloric acid and then with distilled water until free from acid. It was finally dried over KOH. 50 mgms. of each fraction obtained above was dissolved in 50 cc. of N-NaOH and diluted to 25 cc. with distilled water in volumetric flasks.

Chromatography of humic acids :

In this investigation the two methods of circular and unidimensional paper chromatography were used.

Circular Paper Chromatography :

For running circular paper chromatography pieces of 27 cm. diameter were cut from a sheet of Whatman No. 1 filter paper and 2 μ cc. of each test solution was applied at the centre of paper by means of micro-pipette and dried at room temperature. A mixture of n-Butanol, formic acid and water in the ratio of 10:2:5 was used as a solvent for running the chromatogram. A small hole in the centre of the paper was made and a folded paper wick was introduced into it for the uniform rise of the solvent mixture kept below the circular paper in a petri-dish. The paper was supported on a circular glass stand and was kept in a circular glass trough having an air tight ground glass cover with a small hole in the centre as an exit for excess of vapour of the solvent. The filter paper containing the test solution was run for 24 hours in the above solvent mixture. Next day it was removed and dried at room temperature.

50 mgm. of Bromophenol blue in 75 percent ethanol was used as spraying reagent for detecting the components of different humic acids. The paper after drying was sprayed with the above spraying reagent and the colour was developed at room temperature for 24 hours.

Unidimensional Chromatography of humic acids :

For running unidimensional chromatography a sheet of 15 cm. × 35 cm. of Whatman No. 1 filter paper was cut and the straight line was drawn at a distance of 4 cm. from one end of the paper. The test solution of each humic acid (5μ cc.) was applied as above by means of micro-pipette at a distance of 2·5 cm. from each other and dried at room temperature. It was run in the same solvent mixture as used above in the case of circular chromatography. The solvent was kept in a cylindrical trough placed on two racks at the top of the chromatographic chamber. The end of the paper having the test solution was folded into a V-shaped fold so that the filter paper may not fall during running the chromatogram. It was suspended in the cylindrical trough containing the solvent mixture and was allowed to run for 14 hours. After drying it at room temperature it was finally sprayed with the same reagent used above.

RESULTS AND DISCUSSION

From table 2 it is clear that there is not much difference in the carbon and nitrogen contents and C/N ratios of different humic acids separated from different black soils. The carbon content varies from 54·3 percent to 57·1 percent while the nitrogen content varies from 3·2 percent to 3·8 percent in different humic acids. The humic acid separated from Akola soil possesses lowest C/N ratio of 14·53 while highest C/N ratio of 17·01 is found in the case of humic acid separated from Shahabad soil. The humic acids of Ballia, Mirzapur and Coimbatore possess intermediate values.

After the development of the chromatograms two rose yellow bands appeared in the chromatogram of each humic acid against a bluish-violet background. The band at the periphery of the circular chromatogram was not so prominent as the band near the centre. The rose yellow spots of the unidimensional chromatogram were, though, not very well defined due to the tailing effect of the paper but were still sufficient to show the demarkation between the two components of each humic acid.

In spite of small differences in the carbon and nitrogen contents and C/N ratios of different humic acids, the formation of similar bands in the chromatogram of each humic acid seems to indicate that they are of similar nature. The formation of two bands, one fainter and narrower than the other, was probably due to the presence of two fractions in each humic acid. The band at the periphery was narrower and fainter in intensity and was probably produced due to the low concentration of one of the fractions, while that which was formed near the centre was due to higher concentration.

Although there are differences in the parent materials of these black soils (Table no. 1) their humic acid fractions show remarkable similarity in their chromatographic behaviour, suggesting thereby that the formation of organic matter of these soils might have been under somewhat similar conditions.

ACKNOWLEDGEMENTS

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FINITE BENDING OF PLATES—II

By

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1. INTRODUCTION

In part—I (1) one of the authors obtained an exact solution for the problem of bending of an isotropic circular plate into a spherical shell on the basis of linear stress-strain relations (2). In this paper, it is proposed to extend the theory to the case of an aelotropic circular plate assuming the aelotropy to be of hexogonal or rhombohedral type.

2. COMPONENTS OF STRAIN AND STRESS-STRAIN RELATIONS

Let a circular plate in the undeformed state be bent into a spherical shell of inner radius ι and outer radius b and edge $\theta = \infty$. Then, as in the isotropic case (1), the finite displacements in polar coordinates are given by

$$u_r = r - f \cos\theta - F \sin\theta$$
$$u_\theta = f \sin\theta - F \cos\theta$$
$$u_\phi = 0 \tag{2.1}$$

where f and F are functions of r and θ respectively.

The finite components of strain in the deformed state are given by

$$2\,e_{rr} = 1 - f'^2, \quad 2\,e_{\theta\theta} = 1 - F'^2/r^2$$
$$2\,e_{\phi\phi} = 1 - F^2/r^2 \sin^2\theta$$
$$e_{r\theta} = e_{\theta\phi} = e_{\phi r} = 0 \tag{2.2}$$

where $f' = \dfrac{df}{dr}$ and $F' = \dfrac{dF}{d\theta}$.

The non vanishing stresses are given by (3)

$$\widehat{rr} = c_{33}\,e_{rr} + c_{13}\,(e_{\theta\theta} + e_{\phi\phi})$$
$$\widehat{\theta\theta} = \widehat{\phi\phi} = (c_{11}\,e_{\theta\theta} + (c_{11} - 2c_{66})\,e_{\phi\phi} + c_{13}\,e_{rr}. \tag{2.3}$$

Substituting (2.2) in (2.3) we get

$$2\,\widehat{rr} = c_{33}\,(1 - f'^2) + c_{13}\left(2 - \frac{F'^2}{r^2} - \frac{F^2}{r^2 \sin^2\theta}\right)$$

$$2\,\widehat{\theta\theta} = 2\,\widehat{\phi\phi} = c_{13}\,(1 - f'^2) + (c_{11} - 2c_{66})\left(1 - \frac{F^2}{r^2 \sin^2\theta}\right) + c_{11}\,(1 - F'^2/r^2) \tag{2.4}$$

3. EQUATIONS OF EQUILIBRIUM AND BOUNDARY CONDITIONS

The first and second equations of equilibrium in case of no external forces are satisfied if

$$\frac{\partial \widehat{rr}}{\partial r} + \frac{2\widehat{rr} - \widehat{\theta\theta}}{r} \; \widehat{\phi\phi} = 0 \; , \tag{3.1}$$

$$\frac{\partial \widehat{\theta\theta}}{\partial \theta} = 0 \tag{3.2}$$

which give

$$c_{11} F'^2 + (c_{11} - 2c_{66}) \; (F^2/\sin^2\theta) = \frac{c_{33} \, r^3}{2} \; \frac{df'^2}{dr}$$

$$+ (c_{33} - c_{13}) \, r^2 f'^2 - r^2 (c_{33} + c_{13} - 2c_{11} + 2c_{66}) \tag{3.3}$$

$$c_{11} F'^2 + (c_{11} - 2c_{66}) \; (F^2/\sin^2\theta) = k_0^2, \text{ a constant} \tag{3.4}$$

and the third is identically satisfied.

Substituting (3.4) in (3.3) and integrating, we get

$$f'^2 = (\beta/\delta) + 2k_0^2/(\delta - 2) \, c_{33} \, r^2 + (k_1/r^\delta) \tag{3.5}$$

where $c_{33} \beta = 2(c_{33} + c_{13} - 2c_{11} + 2c_{66})$, $c_{33} \delta = 2 (c_{33} - c_{13})$ and k_1 is an arbitrary constant.

As it is not possible to obtain a general solution of the non-linear differential equation (3.4), we assume that the maximum value of θ (= the radius of the circular plate in the deformed state/the radius of the spherical shell) is so small that $\sin\theta = \theta$

Then the equation becomes

$$c_{11} \, \theta^2 \, F'^2 + (c_{11} - 2c_{66}) \, F^2 = k_0^2 \, \theta^2$$

which admits a solution, in conformity with the solution for the isotropic plate (1), of the form

$$F = k_2 \, \theta \tag{3.6}$$

where $k_2^2 = k_0^2/2 (c_{11} - c_{66})$.

Substituting (3.5) and (3.6) in (2.4), we get

$$\widehat{2rr} = A - B \, k_0^2/r^2 - k_1 \, c_{33}/r^\delta \tag{3.7}$$

$$2\widehat{\phi\phi} = 2\widehat{\theta\theta} = C - D \, k_0^2/r^2 - k_1 \, c_{13}/r^\delta \tag{3.8}$$

where $A = 2c_{13} + c_{33} - \beta \, c_{33}/\delta$.

$B = 2/(\delta - 2) + c_{13}/(c_{11} - c_{66})$

$C = 2(c_{11} - c_{66}) + c_{13} - \beta c_{13}/\delta$

$D = 1 + 2c_{13}/(\delta - 2) c_{33}$.

If the inner and outer surfaces of the shell are free from tractions, we should have

$$\widehat{rr} = 0 \text{ when } r = a \text{ and } r = b \tag{3.9}$$

which give

$$B k_0^2/a^2 + k_1 c_{33}/a^\delta = A \tag{3.10}$$

$$B k_0^2/b^2 + k_1 c_{33}/b^\delta = A \tag{3.11}$$

Solving these, we get

$$B k_0^2 = A (a^\delta - b^\delta)/(a^{\delta-2} - b^{\delta-2}) \tag{3.12}$$

$$c_{33} k_1 = A (a^2 - b^2)/(a^{2-\delta} - b^{2-\delta}) \tag{3.13}$$

On the edge $\theta = \infty$, we have

$$\sin \infty \int_a^b \widehat{\theta\theta} \, r \, dr = 0$$

because from the equation of equilibrium (3.1), the equation (3.8) and the boundary conditions (3.9), we have

$$2 \int_a^b r\widehat{\theta\theta} \, dr = \int_a^b \frac{\partial}{\partial r} (r^2 \widehat{rr}) \, dr = (r^2 \widehat{rr})_a^b = 0$$

Therefore the distributions of tractions on the edge $\theta = \alpha$ give rise to a couple of moment M given by

$$M = \sin \infty \int_a^b \widehat{\theta\theta} \, r^2 \, dr \tag{3.14}$$

which on substitution from (3.8) gives

$$2M = \sin \infty \left[\frac{C (b^3 - a^3)}{3} - D k_0^2 (b - a) - \frac{k_1 c_{13} (b^{3-\delta} - a^{3-\delta})}{(3-\delta)} \right]$$

Thus we require a couple of moment M to keep the plate bent into a spherical surface of inner radius a and outer radius b, the curved surfaces $r = a$ and $r = b$ being free from tractions.

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SOME COUNTER EXAMPLES TO THE APPROACH OF V. LAKSHMI-KANTHAM AND J. RAMAKANTH IN SOLVING SOME NON-LINEAR DIFFERENTIAL EQUATIONS

By

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1. For the problems of aelotropic tubes and shells under uniform pressures, B. R. Seth [1] has derived the relevant (non-linear) differential equations and has indicated graphical solutions for the same. Now V. Lakshmikantham and J. Ramakanth claim [2] to have obtained analytic solutions in place of these graphical solutions. Their approach is to assume a solution in a power series of positive powers and to argue it to be convergent by a sequence of wrong steps. They follow the same method in some other papers too : [3], [4] (this is a duplication of [3]), [5]. Their arguments, if correct, would enable one to show the convergence of a solution in power series of any non-linear differential equation. The object of the present paper is to bring to the attention of the readers, by considering some specific equations, the mathematically wrong steps employed.

2. In this section we give, for ready reference, an outline of their approach applied to one of their own equations [2]

$$(p + r\frac{dp}{dr}) \; \frac{d^2p}{dr^2} + (c_1 + 1) \; (\frac{dp}{dr})^2 + \frac{4p}{r} \; \frac{dp}{dr} - c_2 \frac{1-p^2}{r^2} = 0 \qquad (2\cdot1)^*$$

where c_1 and c_2 are constants.

The substitution $\quad r = e^t \qquad\qquad\qquad\qquad\qquad\qquad\qquad (2\cdot2)$

reduces $(2\cdot1)$ to

$$(p + p') \, p'' + c_1 p'^2 + 3 \, p \, p' - c_2 (1 - p^2) = 0 \qquad (2\cdot3)$$

where $p' = \frac{dp}{dt}$ and $p'' = \frac{d^2p}{dt^2}$.

Assuming the solution of $(2\cdot3)$ as

$$p(t) = a_0 + a_1 t + a_2 t^2 + \ldots\ldots + a_n t^n + \ldots + \ldots \qquad (2\cdot4)$$

they get

$$a_2 = \lceil c_2 (1 - a_1^2) - 3 \, a_0 a_1 - c_1 a_1^2 \rceil / 2 \, (a_0 + a_1)$$

$$\sim a_3 = [2 \, c_2 a_0 a_1 + 4 \, a_1^2 + 2 \, a_2 \{3a_0 + (2c_1 + 1) \, a_1\}]/6 \, (a_0 + a_1)$$

and so on where a_n is a function of a_0 and a_1 when $n > 1$.

Dividing $(2\cdot3)$ by p and making the successive substitutions

$$\gamma = p'/p, \, y = 1 + \gamma, z = 1/y, v + 1 = z \qquad (2\cdot5)$$

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* J. Ramakanth [6] tried, by an incorrect method, to obtain analytic solution for this equation with c_1 in place of $(c_1 + 1)$ and zero in place of c_2. See appendix at the end.

ty get

$$v' = (c_1 - 3) v^3 + (c_1 - 7)v^2 - 3v + c_2 (v + 1)^3 [\exp (2t - 2\int \frac{dt}{v + 1}) - 1]$$

$$= f(t, v), \text{ say.} \tag{2.6}$$

Now for the region $0 < t_0 \leqslant t < \infty$ and $1 \leqslant v \leqslant c$ where c is a constant

$$|f(t, v)| \leqslant 4c (c + 1)^2 v + c_2 (c + 1)^3 \exp (\frac{2ct}{c + 1}) v = h(t, v), \text{ say.} \tag{2.7}$$

The solution of the differential equation

$$v' = h(t, v)$$

is $v = \exp \left[4c (c + 1)^2 t\right] + \dfrac{c_2 (c + 1)^4}{2c} \exp (\dfrac{2ct}{c + 1}) = R(t), \text{ say}$

Now appealing to a lemma in [7], they manage to arrive at a wrong result

$$|v(t)| \leqslant R(t) \text{ for } t_0 \leqslant t < \infty \tag{2.8}$$

where $R(t)$ is analytic in the region $t_0 \leqslant t < \infty$ (but may not be bounded) From this they conclude that $v(t)$ is bounded which is quite unnecessary, for what they intended to show they had already assumed in the inequality $1 \leqslant v \leqslant c$. From this they jump to the conclusion that the power series of $v(t)$ converges absolutely. Further, by the dubious argument of "Going through the substitutions in the reverse order", they say, they obtain a unique (?) solution in power series of the equation (2.3) which will also be convergent for $t_0 \leqslant t < \infty$ (?).

3. We now give two counter examples to their method.

Counter Example 1. Consider the equation

$$t^2 p'' + t (t - 1) p' + p = 0 \tag{3.1}$$

and closely follow their method of solution.

Assuming the solution of this equation in the form (2.4) we get

$a_0 = 0$, $a_1 = a_2$ and $a_n = (n - 1)! a_1, n > 1$.

Therefore

$$p(t) = a_1 [t + t^2 + 2! t^3 + \ldots\ldots + n! t^{n+1} + \ldots] \tag{3.2}$$

which converges only when $t = 0$.

Now dividing (3.1) by p and making the substitutions (2.5) and proceeding as they do, we get the equations corresponding to (2.6), (2.7) and (2.8) as

$$v' = v^2 + (v + 1)^2/(t^3) + v (v + 1)/(t^2) - v (v + 1)/(t) = f(t, v), \text{ say} \tag{3.3}$$

and for the region $0 < t_0 \leqslant t < \infty, 1 \leqslant v \leqslant c$

$$|f(t, v)| \leqslant |v^2 + \frac{(v + 1)^2}{t^3} + \frac{v(v + 1)}{t^2}| + |\frac{v(v + 1)}{t}|$$

$$\leqslant \left[c + \frac{(c+1)^2}{t_0^3} + \frac{(c+1)}{t_0^2} + \frac{(c+1)}{t_0} \right] v = h(t,v), \text{ say.} \tag{3.4}$$

$$|v(t)| \leqslant \exp\left[c + \frac{(c+1)^2}{t_0^3} + \frac{(c+1)}{t_0^2} + \frac{(c+1)}{t_0} \right] t = R(t), \text{ say.} \tag{3.5}$$

and hence the series (3.2) must be convergent for $t_0 \leqslant t < \infty$ which is absurd, for the series converges only when $t = 0$.

Counter Example II : Consider the equation

$$(1+t)p'' + p' = 0 \tag{3.6}$$

and closely follow their method of solution.

Assuming the solution of this equation in the from (2.4), we get

$$a_n = (-1)^{n-1} a_1/n \text{ when } n \geqslant 1 \text{ so that}$$

$$p(t) = a_0 + a_1 [t - t^2/2 + \ldots\ldots + (-1)^{n-1} t^n/n + \ldots] \tag{3.7}$$

This is the logarthmic series which is convergent for $0 \leqslant t \leqslant 1$ (only positive values of t are considered).

Now dividing (3.6) by p and the making the substitutions (2.5) and proceeding as they do, we get the equations corresponding to (2.6), (2.7), and (2.8) as

$$v' = v^2 - \frac{v(v+1)}{1+t} = f(t,v), \text{ say.} \tag{3.8}$$

and that for the region $0 \leqslant t_0 \leqslant t < \infty, 1 \leqslant v \leqslant c$

$$|f(t,v)| \leqslant |v^2| + |v(v+1)| \leqslant (2c+1)v = h(t,v), \text{ say.} \tag{3.9}$$

$$|v(t)| \leqslant \exp(2c+1)t = R(t), \text{ say.} \tag{3.10}$$

and hence the series (3.7) must be convergent for $t_0 \leqslant t < \infty$ which is absurd, for the series is convergent only when $0 \leqslant t \leqslant 1$ (only positive values of t are considered).

APPENDIX

Putting c_1 in place of $(c_1 + 1)$ and zero in place of c_2 in (2.1)

and making the substitutions (2.2) and (2.5) J. Ramakanta [6] gets

$$v' + (4 - c_1)v^3 + (6 - c_1)v^2 + 3v = 0 \tag{A.1}$$

Therefore

$$-3t = \log v - \tfrac{1}{2} \log [(4-c_1)v^2 + (6-c_1)v + 3]$$

$$+ \frac{(6-c_1)}{\sqrt{12-c_1^2}} \tan^{-1} \frac{2(4-c_1)v + (6-c_1)}{\sqrt{12-c_1^2}} \tag{A.2}$$

From this he concludes, without proper regard for the reversion of power series, that "v can be expanded in a uniformly convergent power series in t", and, by flatly asserting that "Going through the substitutions in the reverse order", an analytic solution of the given equation can be obtained which converges in the

region not containing $r = 0$ to which $v = 0$ corresponds. This is obviously deceiving, for from (2·2) and (A·2) it is clear that $v = 0$ corresponds to $r = \infty$, and $r = 0$ corresponds to $v = \infty$. He employs the same wrong arguments to solve some other non-linear differential equations [6], [8] and [9] derived by others [10], [11], [12] in solving the problems of isotropic tubes and shells under uniform pressures and dislocations of first order, graphically.

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ON q-LAPLACE TRANSFORMS

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I. INTRODUCTION

A few years back Hahn [3] defined two q-analogues of the well-known Laplace Transform by the help of the integral equations :—

$$_q L_s f(x) = \frac{1}{1-q} \overset{s^{-1}}{\underset{0}{S}} E_q (qsx) f(x) \, d \, (q, x) \tag{1.1}$$

$$_q \pounds_s f(x) = \frac{1}{1-q} \overset{\infty}{\underset{0}{S}} e_q (-sx) f(x) \, d(q, x) \tag{1.2}$$

Rl $(s) > 0$.

In this paper I have made a systematic study of the properties of the $_q L_s$ operator (1.1) and have established certain rules analogous to the corresponding theorems of Laplace transform theory [6]. As shown later, the theory developed provides a powerful tool in handling the q-functions and the q-difference equations.

II. DEFINITIONS AND NOTATION

In what follows the following notation is used :

$$(q; n) = (1-q) \, (1-q^2) \, \ldots \, (1-q^n) \quad \text{where } 0 < q < 1.$$

$$(q; \infty) = \prod_{n=1}^{\infty} (1 - q^n)$$

$$(1+x)_\nu = \prod_{n=0}^{\infty} \frac{1+xq^n}{1+xq^{n+\nu}}$$

$$(1+x) \infty = \prod_{n=0}^{\infty} (1 + xq^n)$$

$$e_q (x) = \sum_{r=0}^{\infty} x^r / (q;r)$$

$$E_q (x) = \sum_{r=0}^{\infty} (-)^r \, q^{\frac{1}{2}r (r-1)} \, x^r / (q;r)$$

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$$\sin_q x = \sum_{r=0}^{\infty} (-)^r x^{2r+1}/(q; 2r+1)$$

$$\cos_q x = \sum_{r=0}^{\infty} (-)^r x^{2r}/(q; 2r)$$

$$\mathrm{Sin}_q x = \sum_{r=0}^{\infty} (-)^r q^{r(2r+1)} x^{2r+1}/(q; 2r+1)$$

$$\mathrm{Cos}_q x = \sum_{r=0}^{\infty} (-)^r q^{r(2r-1)} x^{2r}/(q; 2r)$$

The Heine Series

is denoted by ${}_m\varphi_n (q^{a_1}, \ldots, q^{a_m}; q^{b_1}, \ldots, q^{b_n}; x)$

$$= \frac{(q; b_1 - 1)(q; b_2 - 1) \ldots q; b_n - 1)}{(q; a_1 - 1)(q; a_2 - 1) \ldots (q; a_m - 1)} \times$$

$$\times \sum_{r=0}^{\infty} \frac{(q; a_1 + r - 1)(q; a_2 + r - 1) \ldots (q; a_m + r - 1)}{(q; b_1 + r - 1)(q; b_2 + r - 1) \ldots (q; b_n + r - 1)} \cdot \frac{x^r}{(q; r)}.$$

The k-confluent Series

$$_{n\text{-}k}\Phi_{n-1} (q^{a_1}, \ldots, q^{a_{n-k}}; q^{b_1}, \ldots, q^{b_{n-1}}; x)$$

is defined by:

$$\frac{(q; b_1 - 1) \ldots (q; b_{n-1} - 1)}{(q; a_1 - 1) \ldots (q; a_{n-k} - 1)} \times$$

$$\times \sum_{r=0}^{\infty} (-)^{rk} q^{\frac{1}{2}kr(r-1)} \frac{(q; a_1 + r - 1) \ldots (q; a_{n-k} + r - 1)}{(q; b_1 + r - 1) \ldots (q; b_{n-1} + r - 1)} \cdot \frac{x^r}{(q; r)}.$$

If a function $f(x)$ can be expressed in the form :

$$f(x) = \sum_{r=0}^{\infty} a_r x^r,$$

the function

$$\sum_{r=0}^{\infty} a_r (1 - x)_q$$

is denoted by $f[x]$.

The q – difference operator ϑ is defined by :

$$\vartheta f(x) = \vartheta_x f(x) = \frac{f(qx) - f(x)}{x(q-1)}.$$

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A repeated application of the ϑ operator n times is denoted by $\vartheta_x^{(n)}$ or simply by $\vartheta^{(n)}$.

Following Jackson the inverse of the equation $\vartheta\, F(x) = f(x)$ defines q-integration. The definite q-integrals are defined by means of the infinite series

$$\overset{x}{\underset{0}{S}} f(y)\, d(q,y) = x(1-q) \sum_{i=0}^{\infty} q^i\, f(q^i\, x),$$

$$\overset{\infty}{\underset{n}{S}} f(y)\, d(q,y) = x(1-q) \sum_{i=1}^{\infty} q^{-i}\, f(q^{-i}\, x),$$

$$\overset{\infty}{\underset{0}{S}} f(y)\, d(q,y) = (1-q) \sum_{i=-\infty}^{\infty} q^i f(q^i).$$

In a similar manner the n-repeated integral obtained by repeating the operator n times is symbolically denoted as $\vartheta^{(-n)}$ or $[S\, d\, (q,x)]^n$.

The correspondence

$$\varphi(s) = {}_q L_s\, f(x)$$

$$= 1/(1-q) \overset{s^{-1}}{\underset{0}{S}} E_q(qsx)\, f(x)\, d(q,x)$$

$$= \frac{(q;\infty)}{s} \sum_{j=0}^{\infty} \frac{q^j\, f(s^{-1}q^j)}{(q;j)}$$

shall be denoted by

$$f(x) \supset_q \varphi(s).$$

In a similar manner the functional relation

$$\phi(s) = {}_q \mathcal{L}_s\, f(x)$$

$$= 1/(1-q) \overset{\infty}{\underset{0}{S}} e_q(-sx)\, f(x)\, d(q,x)$$

$$= 1/(1+s)_\infty \sum_{j=-\infty}^{\infty} q^j\, f(q^j)\, (1+s)_j$$

shall be denoted by :

$$f(x) \supset_Q \phi(s).$$

In either case the function $f(x)$ s called the original function and the functions $\varphi(s)$ and $\phi(s)$ are respectively termed as the q-Laplace transform (or the q-image) and the Q-Laplace transform (or the Q-image) of the original function $f(x)$.

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III. FUNDAMENTAL RULES

Rule 1.

Using the above definition of q-Laplace transform, it is easy to see that ;

$$_q L_s\, f(ax) = 1/(1-q)\ \overset{s^{-1}}{\underset{0}{S}}\ E_q\,(qsx)\,f(ax)\,d(q,\,x)$$

$$= 1/a \cdot 1/(1-q)\ \overset{as^{-1}}{\underset{0}{S}}\ E_q\,(qsy)\,f(y)\,d(q,\,y)$$

$$= (1/a)\ \varphi\,(s/a).$$

Thus we obtain

$$\textit{If}$$

$$f(x) \supset_q\ \varphi\,(s)$$

$$\textit{then,}$$

$$f(ax) \supset_q (1/a)\,\varphi\,(s/a).$$

This is analogous to the classical result that

$$f(at) \supset\ \varphi\,(p/a) \text{ where } f(t) \supset\ \varphi\,(p).$$

Rule 2. The q-Differentiation Theorem.

Hahn [3] has shown that

$$_q L_s\, \vartheta_x f(x) = 1/(1-q)\ [s\ _q L_s\, f(x) - f(0)] \qquad \ldots \qquad \ldots \qquad \ldots \qquad (1)$$

Repeated application of (1) gives ;

$$_q L_s\, \vartheta_x{}^{(2)}\, f(x) = {}_q L_s\, \vartheta_x f^{(1)}\,(x) \text{ where } f^{(1)}\,(x) = \vartheta_x f(x)$$

$$= 1/(1-q)\ [s\ _q L_s\, f^{(1)}\,(x) - f^{(1)}\,(0)]$$

$$= 1/(1-q)\ [s/(1-q)\ \{s\ _q L_s\, f(x) - f(0)\} - f^{(1)}\,(0)]$$

$$= (s/(1-q))^2\ _q L_s\, f(x) - f^{(1)}\,(0)/(1-q) + sf(0)/(1-q)^2$$

$$= \left(\frac{s}{1-q}\right)^2\ \varphi\,(s) - \left\{\frac{f^{(1)}\,(0)}{1-q} + \frac{s\,f(0)}{(1-q)^2}\right\}$$

Proceeding in a similar manner

$$\vartheta_x{}^{(3)}\, f(x) \supset_q$$

$$\left(\frac{s}{1-q}\right)^3\ \varphi\,(s) - \left\{\frac{f^{(2)}\,(0)}{1-q} + \frac{s\,f^{(1)}\,(0)}{(1-q)^2} + \frac{s^2\,f(0)}{(1-q)^3}\right\}$$

and in general we get

$$\vartheta_x^{(n)}\, f(x) \supset_q (s/(1-q))^n\ \varphi\,(s) - \overset{n}{\underset{m=1}{\Sigma}}\ f^{(n-m)}\,(0)\ s^{m-1}\,/(1-q)^m$$

$$\textit{where}$$

$$f(x) \supset_q\ \varphi\,(s).$$

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This is analogous to the classical result [7 ; pp. 5]

$$f^{(n)}(x) \supset s^n \varphi(s) - s^{n-1} f(0) \ldots - sf^{(n-2)}(0) - f^{(n-1)}(0).$$

Rule 3. The q-Integration Theorem.

Again setting up the function

$$F_1(x) = 1/(1-q) \int_0^x f(t) \, d(q, t)$$

we have $\quad F_1^{(1)}(x) = f(x)$, where we may suppose $f(0) = 0$, and thus

$$q L_s F_1^{(1)}(x) = q L_s f(x) = 1/(1-q) [s \; q L_s F_1(x) - F_1(0)].$$

or simply :

$$q L_s f(x) = s/(1-q) \; q L_s F_1(x) \text{ since } f(x) \text{ is regular.}$$

By repeated application of the abovementioned process, we obtain the general result

$$\left[\int_0^x Sd \; (q,x) \right]^n f(x) \supset_q ((1-q)/s)^n . \; \varphi(s)$$

for

$$f(x) \supset_q \varphi(s).$$

Rule 4. The Addition Theorem.

It may be seen that for a finite set of original functions $\{ f_r(x) \}$ and the corresponding q-images $\{ \varphi_r(s) \}$, the q-image of the sum-function $\sum\limits_{r=0}^{m} f_r(x)$ is equal to the sum of the q-images of the individual functions. But if we consider an infinite number of functions, we must have :

$$1/(1-q) \int_0^{s^{-1}} E_q(qsx) \left\{ \sum_{r=0}^{\infty} f_r(x) \right\} d(q,x)$$

$$= \sum_{r=0}^{\infty} \left\{ (1/(1-q)) \int_0^{s^{-1}} E_q(qsx) f_r(x) \, d(q,x) \right\}.$$

Writing the integral in the form of a sum :

$$\frac{(q;\infty)}{s} \sum_{r=0}^{\infty} \sum_{j=0}^{\infty} q^j \frac{f_r(s^{-1}q^j)}{(q;j)}$$

a set of sufficient conditions for interchanging the two sums will be [1;pp 81]

(i) $\quad \sum\limits_{r=0}^{\infty} | f_r(x q^j) |$ is convergent for all $x_0 q^j$, x_0 being fixed,

(ii) $\quad q^j \sum\limits_{r=0}^{\infty} | f_r(x q^j) | = O(h^j)$ where j is greater than some fixed J and

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h is a fixed quantity, $|h|$ being less than unity. Hence summing up we obtain the important result that

$$If \qquad f_r\ (x) \supset_q \varphi_r\ (s)$$

then,

$$\sum_{r=0}^{m} f_r\ (x) \supset_q \sum_{r=0}^{m} \varphi_r\ (s) \_$$

provided any one of the following conditions holds :

(a) *m is finite*

(b) *m is infinite and*

(i) $\sum_{r=0}^{\infty} |f_r\ (xq^j\ )|$ *is convergent for each* $x_0\ q^j$,

x_0 *being fixed,*

(ii) $q^j \sum_{r=0}^{\infty} |f_r\ (xq^j)| = O\ (h^j)\ j > J;\ |h| < 1.$

Rule 5.

We set up the integral

$$1/(1-q) \int_{qs}^{\infty} \varphi\ (s)\ d(q,s)$$

where $\varphi\ (s) = 1/(1-q) \int_{0}^{s^{-1}} E_q\ (qsx)\ f(x)\ d(q,x).$

This can be written as $(q\ ;\infty) \sum_{i=1}^{\infty} \sum_{j=0}^{\infty} q^i\ f\ (q^{i+i-1}\ s^{-1})/(q;j)$

The interchange in the orders of integration *i. e,* the two double q-sums is valid if $\sum_{j=0}^{\infty} |f\ (q^j\ s^{-1})|\ /(q;j)$ is convergent—this means that the q-image of $f(x)/x$ exists.

On computation the inner integral reduces to $E_q\ (qsx)/x$ and we obtain

$$(1/(1-q))\ \int_{qs}^{\infty} \varphi\ (s)\ d\ (q,s)$$

$$= (1/(1-q))\ \int_{0}^{s^{-1}} E_q\ (qsx)\ f\ /(x)\ x d\ (q,x)$$

$$= {}_qL_s\ f\ (x)/x$$

This leads to the result

$$If\ f(x) \supset_q \varphi\ (s),\ then$$

$$f(x)/x \supset_q (1/(1-q))\ \int_{qs}^{\infty} \varphi\ (s)\ d\ (q,\ s)$$

provided the q-image of f(x)/x exists.

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Rule 6.

A similar result can be obtained by multiplying the two sides occuring in Rule 1 by $1/(a(1-q))$ and integrating over the interval $(1, \infty)$ with respect to a.

The double q-integral on the left

$$(1/(1-q)) \overset{\infty}{\underset{1}{S}} (1/(1-q)) [\overset{s^{-1}}{\underset{0}{S}} E_q \, (qst) \, f \, (at) \, d \, (q, t) \,]/a \quad d \, (q, a)$$

can be written as

$$\frac{(q \; ; \infty)}{s} \overset{\infty}{\underset{i=1}{\Sigma}} \overset{\infty}{\underset{j=0}{\Sigma}} \frac{q^j \, f \, (q^{i-1} \, s^{-1})}{(q \; ; j)}$$

The interchange in the order of integration is therefore, permissible if the q-sum $\overset{\infty}{\underset{j=0}{\Sigma}} \mid q^j \, f \, (q^i \, s^{-1})/(q \; ; j) \mid$ is convergent, *i. e.* the q-image exists for all s

and provided that $q^j \overset{\infty}{\underset{i=1}{\Sigma}} \mid f \, (q^i \, s^{-1}) \mid = O \, (\mid h \mid ^j)$, *for every fixed j and $\mid h \mid < 1$.*

Accordingly it can be written as

$$(1/(1-q)) \overset{s^{-1}}{\underset{0}{S}} E_q \, (qst) \, [(1/(1-q)) \overset{\infty}{\underset{1}{S}} f \, (at) \, d \, (q, a)/a] \, d(q, t)$$

$$= (1/(1-q)) \overset{s^{-1}}{\underset{0}{S}} E_q \, (qst) \, [(1/(1-q)) \overset{\infty}{\underset{t}{S}} f \, (x)/x \, d \, (q, x)] \, d(q, t)$$

$$= {}_qL_s \, [(1/(1-q)) \overset{\infty}{\underset{x}{S}} f \, (x)/x \, d \, (q, x)].$$

Next, the right-hand side becomes on a change in the variable

$$(1/(1-q)) \overset{\infty}{\underset{1}{S}} (1/a)^2 \, \varphi \, (s/a) \, d \, (q, a) = (1/(q(1-q)) \overset{s}{\underset{0}{S}} \varphi \, (y)/s. \, d \, (q, y).$$

This leads to the theorem

$$\frac{1}{1-q} \overset{\infty}{\underset{x}{S}} \frac{f(x)}{x} \, d \, (q, x)$$

$$\supset_q (1/(qs \, (1-q)) \overset{s}{\underset{0}{S}} \varphi \, (s) \, d \, (q, s)$$

provided

(i) *the two integrals exist,*

(ii) $\varphi \, (s)$ *exists for all s,*

(iii) $q^j \overset{\infty}{\underset{i=1}{\Sigma}} \mid f \, (q^i \, s^{-1}) \mid = O \, (\mid h \mid ^j)$, *for every fixed j and $\mid h \mid < 1$*

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Rule 7.

Now if $F_1(x) = (1/(1-q)) \overset{x}{\underset{0}{S}} f(x)/x . d(q, x)$.

$F_1^{(1)}(x) = f(x)/x$, provided $F_1^{(1)}(0) = 0$.

Using Rule 3, $qL_s F_1^{(1)}(x) = (1/(1-q)) [s \; qL_s F_1(x) - F_1(0)]$

we have,

$$qL_s \; f(x)/x = (s/(1-q)) \; qLs \; \{(1/(1-q)) \overset{x}{\underset{0}{S}} f(x)/x . d(q, x)\} \text{ if } F_1^{(1)}(0) = 0.$$

Combining Rule 5,

$$\frac{s}{1-q} \; qL_s \; \frac{1}{1-q} \overset{x}{\underset{0}{S}} \frac{f(x)}{x} \; d(q,x) = \frac{1}{1-q} \overset{\infty}{\underset{qs}{S}} \varphi(s) \, d(q,s).$$

or simply

$$\frac{1}{1-q} \overset{x}{\underset{0}{S}} \frac{f(x)}{x} \; d(q,x) \supset q \; \frac{1}{s} \overset{\infty}{\underset{qs}{S}} \varphi(s) \, d(q,s)$$

Rule 8.

Lastly, we derive another interesting correspondence which involves the use of both the q. and the Q-images.

Let us consider the function

$$F(x) = 1/(1-q) \overset{\infty}{\underset{0}{S}} (x/y)^{\frac{1}{2}a} \; _q j_a (2\sqrt{xy}) f(y) d(q, y)$$

where $_qJ_a$ is a q-analogue of Bessel function defined as

$$_qJ_a = \frac{(x/2)^a}{(q; a)} \; _2\varphi_1 (0,0; q^{a+1}; - (x/2)^2).$$

Since $_qJ_a(x) = O(a^a)$ for small values of x, and it tends to zero for large x, we can easily see that the q-integral for $F(x)$ converges absolutely provided

(i) $\overset{\infty}{\underset{r=0}{\Sigma}} | q^r \; f(q^r)|$ converges

(ii) $f(q^{-r}) = O(q^{cr})$; $c > 1$ for large values of r.

and (iii) Rl $(a) > 0$.

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So in the double q-integral

$$_q L_a \ F(x) = 1/(1-q)^2 \left\{ \overset{s^{-1}}{\underset{0}{S}} \ E_q \ (qsx) \ \overset{\infty}{\underset{0}{S}} \ (x/y)^{\frac{1}{2}a} \ _q j_a \ (2\sqrt{xy}) \ f(y) d(q,y) \right\} \ d(q,x).$$

an interchange in the order of integration is permissible subject to the above conditions

Since $_q I_s \ x^{k-1} = (q \ ; k-1) \ s^{-k} \ (k > 0)$

we have

$$1/(1-q) \ \overset{s^{-1}}{\underset{0}{S}} \ E_q \ (qsx) \ (x/y)^{\frac{1}{2}a} \ _q j_a \ (2/xy) \ d(q,y) = s^{-a-1} \ e_q \ (-y/s).$$

or,

$$_q L_a \ F(x) = s^{-a-1} /(1-q) \ \overset{\infty}{\underset{0}{S}} \ e_q(-y/s) \ f(y) \ d(q,y).$$

Thus we get the result

If $\phi(s)$ is the Q-image of $f(x)$, then

$$1/(1-q) \ \overset{\infty}{\underset{0}{S}} \ (x/y)^{\frac{1}{2}a} _q j_a \ (2\sqrt{xy}) \ f(y) \ d(q,y) \ \underset{Q}{\supset} \ s^{-a-1} \ \phi(1/s)$$

provided

(i) $\overset{\infty}{\underset{r=0}{\Sigma}} | \ q^r \ f(q^r) | \ converges$

(ii) $f(q^{-r}) = O(q^{cr}) \ , c > 1 \ for \ large \ values \ of \ r$

and (iii) $R1(a) > 0$.

This is analogous to the well-known theorem of Tricomi [8]

$$x^{\frac{1}{2}\nu} \int_0^\infty t^{-\frac{1}{2}\nu} \ J_\nu(2 \sqrt{xt}) \ f(t) \ dt \supset p^{1-\nu} \ \varphi(1/p)$$

where $f(x) \supset \varphi(p)$.

IV. THE $_q\mathcal{L}_s$ OPERATOR

As remarked by Hahn [3 ; pp. 373] the convolution theorem

$$_q L_s \ F(x) \ . \ _q L_s \ G(x) = \ _q L_s \ (F(x) * G(x)),$$

where

$$F(x) * G(x) = (1/(1-q)) \ \overset{1}{\underset{0}{S}} \ F(tx) \ G[t-tqx] \ . \ d(q,t)$$

is only true for $_q L_s$ and not for the $_q \mathcal{L}_s$ transform as defined in Art. 1·2,

It is shown below that whereas the qL_s transform has the above advantage over the $q\mathcal{L}_s$ transform, it suffers from the disadvantage that the q-analogue of the well known Goldstein's Theorem [2 ; pp. 105] is not valid for this and so it is not advantageous in dealing with the evaluation of infinite q-integrals.

Thus it is desirable to study the properties of the $q\mathcal{L}_s$ transform as well in making certain applications. **I give** below the formal rules valid under appropriate conditions, for this transform. The correspondence of rules to qL_s is denoted with an asterisk, thus Rule 1* corresponds to Rule 1 for qL_s of Art. 3.

Rule 1*

$$\text{If} \quad f(x) \supset \phi(s),$$

$$f(ax) \supset_Q (1/a)\,\phi(s/a).$$

Rule 2*

$$\vartheta_x^{(n)} f(x) \supset_Q \left(\frac{s}{q(1-q)}\right)^n \phi\left(\frac{s}{q^n}\right) - \sum_{m=1}^{n} \frac{f^{(n-m)}(0)\,s^{m-1}}{q^{m-1}(1-q)^m}$$

$$\text{for} \quad f(x) \supset_Q \phi(s).$$

Rule 3*

$$\left[\overset{x}{\underset{0}{S}} d(q,x) \right]^n f(x) \supset_Q (q(1-q)/s)^n \,\phi(s/q^n).$$

Rule 4*

$$\sum_{r=0}^{m} f_r(x) \supset_Q \sum_{r=0}^{m} \phi_r(s)$$

where m is subject to conditions similar to that of Rule 4.

Rule 5*

$$f(x)/x \supset_Q (1/(1-q)) \overset{\infty}{\underset{s}{S}} \phi(s)\, d(q,s)$$

Rule 6*

$$(1/(1-q)) \overset{\infty}{\underset{x}{S}} f(x)/x \, d(q,x) \supset_Q (1/(q(1-q)s) \overset{s}{\underset{0}{S}} \phi(s)\,d(q,s).$$

Rule 7*

$$(1/(1-q)) . \overset{x}{\underset{0}{S}} f(x)/x \, d(q,x) \supset_Q (q/s) \overset{\infty}{\underset{0}{S}} \phi(s)\, d(q,s) \quad .$$

In this way it can be seen that the above theorems for the qL_s operator are also valid in the case of $q\mathcal{L}_s$ operator with a modification in the coefficients through an introduction of powers of q and change of the upper limit of integration from s^{-1} to ∞

In addition, many other theorems which are not valid for $_qL_s$ are true in the case of $_q\mathcal{L}_s$ operator.

Consider

$$\phi(s) = 1/(1-q)) \overset{\infty}{\underset{0}{S}} \; e_q \; (-sx) f(x) \, d(q,x)$$

and apply the operator ϑ_s on both sides. On the right-hand side it is possible to use this operator under the sign of q-integration on account of absolute convergence

Thus

$$(1/(1-q)) \overset{\infty}{\underset{0}{S}} \; (1/(1-q)) \, x \, e_q \; (-sx) f(x) \, d(q,x) = -\vartheta_s \; \phi(s) \; ,$$

or $\quad _q\mathcal{L}_s \; (xf(x)) = (q-1) \, \vartheta_s \; \phi(s)$.

Proceeding in a similar manner we obtain the theorem

Theorem I.

$$\text{If} \qquad f(x) \supset_Q \phi(s) \; ,$$

then

$$x^n \; f(x) \supset_Q (q-1)^n \; \vartheta_s^{(n)} \; \phi(s)$$

which is the basic analogue of the well-known result [4;pp 27]

$$t^n \; f(t) \supset (-)^n p \; \frac{d^n}{dp^n} \; (\phi(p)/p).$$

In the above theorem if we take $\vartheta_x^{(m)} \, f(x)$ in place of $f(x)$ we have

$$x^n \; \vartheta_x^{(m)} \; f(x)$$

$$\supset_Q \; (q-1)^n \; \vartheta_s^{(m)} \left[(q(1-q))^{-m} s^m \, \phi \, (s/q^m \; - \; \sum_{r=1}^{m} \frac{f^{m-r}(0) \, s^{r-1}}{q^{r-1} \, (1-q)^r} \right]$$

$$\textit{where } m > n$$

or

$$\supset_Q \; (-)^m \; \frac{(q-1)^{n-m}}{q^m} \; \vartheta_s^{(n)} \left[s^m \, \phi \, (s/q^m) \right]$$

$$\textit{where } m \leqslant n.$$

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Further, consider two functions $f_1(x)$ and $f_2(x)$ and let their ${}_q\mathcal{L}_s$ — images be $\phi_1(s)$ and $\phi_2(s)$.

Setting up the integral

$$(1/(1-q)) \overset{\infty}{\underset{0}{S}} f_1(y)\, \phi_2(y)\, d\,(q.y),$$

we obtain

$$(1/(1-q)) \overset{\infty}{\underset{0}{S}} f_1(y)\, d\,(q,y)\ (1/(-q)) \overset{\infty}{\underset{0}{S}} e_q(-xy)\, f_2(x)\, d\,(q,x)$$

The change in the order of integration is permissible when

$$\overset{\infty}{\underset{0}{S}} \mid f_1(y)\, e_q(-xy)\mid d\,(q,y)$$

and

(A)

$$\overset{\infty}{\underset{0}{S}} \mid f_2(x)\, e_q(-xy)\mid d\,(q,x)$$

converge and the double q-integrals involved exist.

Thus the integral becomes

$$(1/(1-q)) \overset{\infty}{\underset{0}{S}} f_2(x) \left\{ (1/(1-q)) \overset{\infty}{\underset{0}{S}} e_q(-xy) f_1(y)\, d\,(q,y) \right\} d\,(q,x)$$

$$= (1/(1-q)) \overset{\infty}{\underset{0}{S}} f_2(x)\, \phi_1(x)\, d\,(q,x).$$

The conditions (A) imply the existence of the Q-images of $f_1(x)$ and $f_2(x)$ [Hahn; 4, pp 284].

Thus we obtain the important result

Theorem II. q-Goldstein Theorem.

If $\qquad f_1(x) \supset_Q \phi_1(s)$

and

$\qquad\qquad f_2(x) \supset_Q \phi_2(s)$,

then

$$\overset{\infty}{\underset{0}{S}} f_1(x)\, \phi_2(x)\, d\,(q,x) = \overset{\infty}{\underset{0}{S}} f_2(x)\, \phi_1(x)\, d\,(q\,x)$$

provided :

(i) the two integrals exist :

(ii) $q^{\frac{1}{2}i(i-1)} f_1(q^{-i}) = O\,(R^i)$, $j \to \infty$

(iii) $q^{\frac{1}{2}j(j-1)} f_2(q^{-j}) \supset = (R^j)$, $j \to \infty$

where $\mid s \mid$ is greater than a fixed quantity R, R $<$ 1,

[400]

The above theorem is a generalisation of the classical Goldstein Theorem. [2; pp 105].

As an illustration of the above theorem, we take $f_1(x) = x^{\rho - 1}$ and $f_2(x) = x^{\lambda - 1} {}_1\Phi_1(q^\alpha ; q^\beta ; tx)$ where $Rl(\rho)$ and $Rl(\lambda)$ are positive.

Therefore [4; pp 290].

$$\phi_1(x) = (q;\rho - 1) \frac{(1 + xq^\rho)_\infty (1 + q^{1-\rho} x^{-1})_\infty}{(1+x)_\infty (1+qx^{-1})_\infty}$$

$$\phi_2(x) = (q;\lambda - 1) \frac{(1 + xq^\lambda)_\infty (1 + q^{1+\lambda} x^{-1})_\infty}{(1+x)_\infty (1+qx^{-1})_\infty} \cdot {}_2\varphi_1(q^\alpha , q^\lambda ; q^\beta ; -tq^\lambda /x)$$

According to our q-Goldstein Theorem

$$\overset{\infty}{\underset{0}{S}} (q; \lambda - 1) x^{\rho - 1} \frac{(1 + xq^\lambda)_\infty (1 + q^{1-\lambda} x^{-1})_\infty}{(1+x)_\infty (1+qx^{-1})_\infty} \cdot {}_2\varphi_1(q^\alpha , q^\lambda ; q^\beta ; -tq^\lambda/x)$$

$$d(q,x)$$

$$= \overset{\infty}{\underset{0}{S}} (q;\rho - 1) x^{\lambda - 1} \frac{(1 + xq^\rho)_\infty (1 + q^{1-\rho} x^{-1})_\infty}{(1+x)_\infty (1+qx^{-1})_\infty} \cdot {}_1\Phi_1(q^\alpha ; q^\beta ; tx) d(q,x) 1$$

Writing the L. H. S. integral as a q-sum we have

$$(q ; \lambda - 1) \overset{\infty}{\underset{j=0}{\Sigma}} q^{\rho j} \frac{(1+q^{\lambda + j})_\infty (1+q^{1-\lambda - j})_\infty}{(1+q^j)_\infty (1+q^{1-j})_\infty} {}_1\Phi_1(q^\alpha , q^\lambda ; q^\beta ; -tq^{\lambda - j})$$

$$+ (q ; \lambda - 1) \overset{\infty}{\underset{i=1}{\Sigma}} q^{-\rho i} \frac{(1+q^{\lambda - i})_\infty (1+q^{1-\lambda + i})_\infty}{(1+q^{-i})_\infty (1+q^{1+i})_\infty} {}_1\Phi_1(q^\alpha , q^\lambda ; q^\beta ; -tq^{\lambda + i})$$

Because [4 ; pp. 290]

$$\frac{(1+q^{\lambda + j})_\infty}{(1+q^j)_\infty} = O(1),$$

$$\frac{(1+q^{1-\lambda - j})_\infty}{(1+q^{1-j})_\infty} = O(q^{-\lambda j})$$

and

$${}_2\varphi_1(q^\alpha , q^\lambda ; q^\beta ; -tq^{\lambda - j}) = O(q^{\lambda j}),$$

the general term of the j-series is asymptotically equal to $q^{\rho j}$.

Hence the j-branch is absolutely convergent for $Rl(\rho) > 0$.

Similarly in the i-branch the general term $\sim q^{(\lambda-\rho)i}$.

For absolute convergence $\mathrm{Rl}\,(\lambda-\rho) > 0$.

Thus the L. H. S. integral converges absolutely for $\mathrm{Rl}\,(\lambda) > \mathrm{Rl}\,(\rho) > 0$.

Now, the R. H. S. integral can be written as

$$(q;\rho-1)\sum_{j=0}^{\infty} q^{\lambda j}\,\frac{(1+q^{\rho+j})_{\infty}\,(1+q^{1-\rho-j})_{\infty}}{(1+q^{j})_{\infty}\,(1+q^{1-j})_{\infty}}\;\;_1\Phi_1(q^{\alpha};q^{\beta};tq^{j})$$

$$+ (q;\rho-1)\sum_{i=1}^{\infty} q^{-\lambda i}\,\frac{(1+q^{\rho-i})_{\infty}\,(1+q^{1-\rho+i})_{\infty}}{(1+q^{-i})_{\infty}\,(1+q^{1+i})_{\infty}}\;\;_1\Phi_1(q^{\alpha};q^{\beta};tq^{-i}).$$

In the j-series, because

$$\frac{(1+q^{\rho+j})_{\infty}}{(1+q^{j})_{\infty}} = O\,(1)$$

$$\frac{(1+q^{1-\rho-j})_{\infty}}{(1+q^{1-j})_{\infty}} = O\,(q^{-\rho j})$$

and
$$_1\Phi_1(q^{\alpha};q^{\beta};tq^{j}) = O\,(1)$$

the general term is asymptotic to $q^{(\lambda-\rho)j}$.

Thus the existence and absolute convergence of this branch is assured : $\mathrm{Rl}\,(\lambda) > \mathrm{Rl}\,(\rho) > 0$ *i. e.* if the L. H. S. integral converges absolutely.

In the second branch

$$\frac{(1+q^{1-\rho+i})_{\infty}}{(1+q^{1+i})_{\infty}} = O\,(1)$$

and

$$\frac{(1+q^{\rho-i})_{\infty}}{(1+q^{-i})_{\infty}} = O\,(q^{(1+i)\rho})$$

Moreover [4 ; pp. 288] for large positive or negative x, the k-confluent serie

$$_{n-k}\Phi_{n-1}(x) \sim exp\,\frac{(\log x + \frac{1}{2}\,|\,\log q\,|\,)^2}{|\,2k\,\log q\,|}$$

so, $_1\Phi_1(q^{\alpha};q^{\beta};tq^{-i}) \sim q^{\frac{1}{2}i\,(i+c)}$

This series converges absolutely.

Thus the two integrals converge absolutely for $\mathrm{Rl}\,(\lambda) > \mathrm{Rl}\,(\rho) > 0$.

The integral (1) can be evaluated in terms of simple functions in certain particular cases.

(A) For example, let $\rho = n$ (a positive integer).

The integral becomes

$$\int_0^\infty x^{n-1} \frac{(1+xq^\lambda)_\infty (1-q^{1-\lambda} x^{-1})_\infty}{(1+x)_\infty (1+qx^{-1})_\infty} \, {}_2\Phi_1 (q^\alpha ; q^\lambda ; q^\beta ; tq^\lambda /x) \, d(q,x)$$

$$= q^{-\frac{1}{2}n(n-1)} \frac{(q;n-1)}{(q;\lambda-1)} \int_0^\infty x^{\lambda-n-1} \, {}_1\Phi_1 (q^\alpha ; q^\beta ; tx) \, d(q,x) \qquad (2)$$

In order to evaluate the R. H. S. integral we make use of an important theorem due to Jackson [5;pp8]

$$\int_0^\infty F(-x)^{s-1} \, d(q,x) = A(-s) \, G[s]$$

where $F(-x)$ is absolutely and uniformly convergent being expressed as a q-sum

$$F(-x) = \sum_{r=0}^\infty (-)^r A(r) \, x^r /(q;r);$$

and $G[s]$ is a Jackson q-analogue of Gamma function, defined as

$$G[s] = \int_0^\infty x^s e_q(x) \, d(q,x) \qquad (3)$$

Hence

$$\int_0^\infty x^{n-1} \frac{(1+xq^\lambda)_\infty (1+q^{1-\lambda} x^{-1})_\infty}{(1+x)_\infty (1+qx^{-1})_\infty} \, {}_2\varphi_1 (q^\alpha , q^\lambda ; q^\beta ; -tq^\lambda /x) \, d(q,x)$$

$$= \frac{(q;n-1)(q;\beta-1)(q;\alpha-\lambda+n-1)}{(q;\lambda-1)(q;\alpha-1)(q;\beta-\lambda+n-1)} \, q^{\frac{1}{2}\lambda(\lambda+1)-n\lambda} \, t^{n-\lambda} \, G[\lambda-n]. \qquad (4)$$

(B) In (1) taking $\lambda = m$ (a positive integer) we have :

$$\int_0^\infty x^{m-1} \, {}_1\varphi_0 (q^\rho ; -x) \, {}_1\varphi_0 (q^{-\rho}; -q/x) \, {}_1\Phi_1 (q^\alpha ; q^\beta ; tx) \, d(q,x)$$

$$= \frac{(q;m-1)}{(q;\rho-1)} \, q^{\frac{1}{2}m(m-1)} \int_0^\infty x^{\rho-m-1} \, {}_2\varphi_1 (q^\alpha, q^m ; q^\beta ; -tq^m /x) \, d(q,x) .$$

Evaluating the R. H. S. integral by a change in the variable we obtain :

$$\frac{(q;\rho-1)(q;\beta-1)(q;\alpha-m+\rho-1)}{(q;m-1)(q;\alpha-1)(q;\beta-m+\rho-1)} \, q^{-m(m-\rho)-\frac{1}{2}m(m-1)+1} .$$

$$\times t^{-m+\rho} G[m-\rho].$$

Hence

$$\mathop{S}\limits_{0}^{\infty} \quad x^{m-1} \quad {}_1\varphi_0 \ (q^\rho \ ; \ -x) \ {}_1\varphi_0 \ (q^{-\rho}; \ -q/x) \ {}_1\varphi_1 \ (q^\alpha \ ; \ q^\beta \ ; \ tx) \ d \ (q,x)$$

$$= \frac{(q; \beta - 1) \ (q; \alpha + \rho - m - 1)}{(q; \alpha - 1) \ (q; \beta + \rho - m - 1)} \ q^{-\frac{1}{2}m \ (m - 2\rho)+1} \ t^{-m+\rho} \ G \ [m - \rho] \ (5)$$

Now as a general case we take the k — confluent function :

$$f \ (x) = x^{m-1} \ {}_{n-2k}\Phi_n \ (q^{a_1}, \ \ldots \ q^{a_{n-k}} \ ; \ q^{b_1}, \ \ldots \ , q^{b_n} \ ; x)$$

For the sake of simplicity we take m to be a positive integer, so

$$\dot{\phi}_1 \ (x) = (q; m - 1) \ q^{-\frac{1}{2}m \ (m - 1)} \ x^{-m}$$

$$_{n-k+1}\varphi_n \ (q^{a_1}, \ \ldots \ , q^{a_{n-2k}}, q^m \ ; \ q^{b_1} \ , \ \ldots \ , \ q^{b_n} \ ; \ -\frac{1}{q^m . x})$$

If $\quad f_2 \ (x) = x^{\rho-1} \quad \mathrm{Rl} \ (\rho) > 0$,

$$\phi_2 \ (x) = (q; \rho - 1) \ {}_1\varphi_0 \ (q^\rho; \ -x) {}_1\varphi_0 \ (\ q^{-\rho}; \ -q/x) \quad .$$

Hence by our theorem :

$$\mathop{S}\limits_{0}^{\infty} \quad x^{m-1} \ {}_1\varphi_0 \ (q^\rho; \ -x) \ {}_1\varphi_0 \ (q^{-\rho} \ ; \ -q/x)$$

$$\times \ {}_{n-2k} \Phi_n \ (q^{a_1}, \ , \ q^{a_{n-2k}}; q^{b_1}, \ \ldots \ , \ q^{b_n}; x) \ d(q, x)$$

$$= \frac{(q; m-1)}{(q; \rho-1)} \ . \ q^{-\frac{1}{2}m \ (m - 1)}.$$

$$\mathop{S}\limits_{0}^{\infty} x^{\rho-m-1} \ {}_{n-2k+1}\Phi_n \ (q^{a_1} , \ \ldots \ , \ q^{a_{n-2k}}; q^m \ ; q^{b_1}, \ \ldots \ , \ q^{b_n}; \ -\frac{1}{q^m x} \ ) \ d \ (q,x) \ )$$

It is easy to see that the two integrals converge absolutely when $m > \mathrm{Rl} \ (\rho) > 0$.

Evaluating the R. H. S. integral by a change in the variable according to Jackson's method mentioned above, we obtain

$$\mathop{S}\limits_{0}^{\infty} x^{m-1} \ {}_1\varphi_0 \ (q^\rho \ ; \ -x) \ {}_1\varphi_0 \ (q^{-\rho} \ ; -q/x) \ {}_{n-2k}\varphi_n \ (q^{a_1}, \ \ldots \ , \ q^{a_{n-2k}}; q^{b_1}, \ \ldots \ , q^{b_n}; x) \ d \ (q, x).$$

$$= \frac{\displaystyle\prod_{i=1}^{n} (q; b_i - 1) \ \displaystyle\prod_{j=1}^{n-2k} (q; b_j + \rho - m - 1)}{\displaystyle\prod_{i=1}^{n-2k} (q; a_i - 1) \ \displaystyle\prod_{j=1}^{n} (q; b_j + \rho - m - 1)} \ . \ q^{\frac{1}{2}(m-\rho) \ (2k+1) \ (m-\rho+1)+2m)} \times G[m-\rho] \ (6).$$

[404]

V. CERTAIN IMAGES

It is easy to see that [3]

$$x^n \supset_q (q;n) \ s^{-n-1} \quad n > 0,$$

$$x^n \supset_Q (q;n) \ q^{-\frac{1}{2}n(n+1)} \ s^{-n-1} , \ n \text{ being a positive integer}$$

The above results can be utilised to evaluate the images of a large number of functions with the help of the Rules in §§ 3 and 4.

As illustration we take a few q - images involving the use of Addition Theorem (§ 3.4)

$$(i) \ \sin_q (x) = \sum_{r=0}^{\infty} (-)^r \cdot x^{2r+1} /(q ; 2r+1).$$

Hence $qLs \ \sin_q wx = \sum_{r=0}^{\infty} (-)^r \ w^{2r+1} (q ; 2r+1) \ s^{-2r-2} /(q ; 2r+1)$

$$= (w/s^2) \sum_{r=0}^{\infty} (-)^r \ (w/s)^{2r}$$

$$= w/(w^2+s^2) \qquad |w| < |s|$$

$i. e. \quad \sin_q wx \supset_q w/(w^2+s^2)$ 　　　　　　　　　(5.1.1)

$$Sin_q \ wx = \sum_{r=0}^{\infty} (-) \ q^{r(2r+1)} w^{2r+1} \ x^{2r+1} /(q ; 2r+1)$$

so $qLs \ Sin_q (wx) = (w/s^2) \sum_{r=0}^{\infty} (-)^r \ q^{r(2r+1)} \cdot (w/s)^{2r}$

$$= (w/s^2) \ _1\Phi_1 (q' ; 0 ; q'=q^1 ; q^3 w^2/s^2) \qquad (5.1.2)$$

Similarly

$$qLs \ \cos_q wx = qLs \sum_{r=0}^{\infty} (-)^r \ x^{2r} / (q ; 2r)$$

$$= s / (w^2+s^2) \qquad |w| < |s| \qquad (5.1.3)$$

and

$$qLs \ Cos \ wx = qLs \sum_{r=0}^{\infty} (-)^r \ q^{r(2r+1)} (wx)^{2r} / (q ; 2r)$$

$$= (1/s) \ _1\Phi_1 (q' ; 0 ; q'=q^4 ; qw^2/s^2) \qquad (5.1.4)$$

[405]

Summing up, we get the q-images of the elementary q-trigonometric functions as :

$$\sin_q (ux) \supset_q w/(w^2+s^2) \qquad\qquad |w| \prec |s|$$

$$\operatorname{Sin}_q (wx) \supset_q (w/s^2)\,_1\Phi_1 (q' ; 0 ; q'=q^4 ; q^3w^2/s^2)$$

$$\cos_q (wx) \supset_q s/(w^2+s^2) \qquad\qquad |w| \prec |s|$$

$$\operatorname{Cos}_q (wx) \supset_q (1/s)\,_1\Phi_1 (q' ; 0 ; q'=q^4; qw^2/s^2)$$

Next, consider the k-confluent series :

$$F(x) = x^{\rho-1}\,_{n-k}\Phi_{n-1} (q^{a_1},\ldots\ldots, q^{a_{n-k}} ; q^{b_1},\ldots\ldots, q^{b_{n-1}} ; tx)$$

$$= \frac{(q ; b_1-1)\ldots\ldots(q ; b_{n-1}-1)}{(q ; a_1-1)\ldots\ldots(q ; a_{n-k}-1)} \times$$

$$\times \sum_{r=0}^{\infty} (-)^{rk}\, q^{\frac{1}{2}kr(r-1)}\, \frac{(q ; a_1+r-1)\ldots\ldots(q ; a_{n-k}+r-1)}{(q ; b_1+r-1)\ldots\ldots(q ; b_{n-1}+r-1)} \cdot \frac{t^r}{(q ; r)}\, x^{r+\rho-1}$$

Therefore $_qL_s F(x) = \frac{(q ; b_1-1)\ldots\ldots(q ; b_{n-1}-1)}{(q ; a_1-1)\ldots\ldots(q ; a_{n-k}-1)} \times$

$$\times \sum_{r=0}^{\infty} (-)\quad q^{\frac{1}{2}kr(r-1)}\, \frac{(q; a_1 +r-1)\ldots(q; a_{n-k}+r-1)(q; \rho+r-1)}{(q; b_1+r-1)\ldots(q; b_{n-1}+r-1)(q;r)} \frac{t^r}{s^{r+\rho}}$$

$$=(b; \rho-1)\,s^{-\rho} \cdot\,_{n-k+1}\Phi_n (q^{a_1},\ldots\ldots, q^{a_{n-k}}, q^{\rho} ; q^{b_1},\ldots\ldots, q^{b_{n-1}}, 0; t/s) \qquad (5 \cdot 2.1)$$

As a particular case taking $\rho=k=n=1$, we readily obtain :

$$_qL_s E_q (ax) = (1/s)\,_1\Phi_1 (q; 0; a/s) \qquad\qquad (5.2.2)$$

It may be of interest to find also the Q-image of the k-confluent function. Writing the Q-image as :

$$\frac{1}{(1+s)_{\infty}} \sum_{j=-\infty}^{\infty} q^j \cdot\,_{n-k}\Phi_{n-1} (tq^j) (1+s)_j$$

and employing the method used in the previous section (TH II) for ascertaining the existence of an infinite integral, it may be seen that the Q-image exists and is equal to

$$\frac{(q; b_1-1)\ldots\ldots(q; b_{n-1}-1)}{(q; a_1-1)\ldots\ldots(q; a_{n-k}-1)} \times$$

$$\times \sum_{r=0}^{\infty} (-)^{rk} q^{\frac{1}{2}kr(r-1)-\frac{1}{2}(r+\rho)(r-1+\rho)}\frac{(q; a_1+r-1)\ldots(q; a_{n-k}+r-1)(q; \rho+r-1)}{(q; b_1+r-1)\ldots(q; b_{n-1}+r-1)(q; r)} \times$$

$$\times \frac{t^r}{s^{r+\rho}}$$

$$= (q; \rho - 1) \, q^{\frac{1}{2}\rho \, (\rho - 1)} \, s^{-\rho} \cdot \, _{n-k+1}\Phi_{n-1} \, (q^{a_1}, \ldots, q^{a_{n-k}}, q^\rho \; ; q^{b_1}, \ldots, q^{b_{n-1}} \; ; \frac{-t}{q^\rho s})$$

<div align="right">(5.2.3)</div>

As a particular case for $\rho = k = n = 1$,

$$E_q \, (ax) \supset_Q \; q/(a + qs) \qquad |a| < |qs| \tag{5.2.4}$$

Next consider the ordinary Heine Series :

$$F \, (x) = x^{\rho - 1} \, _m\varphi_n \, (q^{a_1}, \ldots, q^{a_m}; q^{b_1}, \ldots, q^{b_n}; tx).$$

This series converges for $|tx| < 1$ when $m = n = 1$ or $m \leqslant n$; [3; pp 345]

So

$$_q L_s \, F \, (x) = \frac{(q; b_1 - 1) \quad \cdots \cdot \, (q; b_m - 1)}{(q; a_1 - 1) \quad \cdots \cdot \, (q; a_n - 1)} \times$$

$$\times \sum_{r=0}^{\infty} \frac{(q; a_1 + r - 1) \cdots \cdot (q; a_m + r - 1) \, (q; \rho + r - 1)}{(q; b_1 + r - 1) \cdots \cdot (q; b_n + r - 1)} \frac{}{(q; r)} \cdot t^r \; s^{-r-\rho}.$$

$$= s^{-\rho} \, (q; \rho - 1) \, _{m+1}\Phi_n \, (q^{a_1}, \ldots, q^{a_m}, q^\rho \; ; q^{b_1}, \ldots, q^{b_n}; t/s)$$

valid for $m \leqslant n$ and $|t| < |s| \quad ; \rho > -1$.

<div align="right">(5.2.5)</div>

As a particular case when $\rho = 1$, $m = 1$, $n = 0$,

$$e_q \, (ax) \supset_q \; 1/(s - a) \qquad |a| < |s| \, . \tag{5.2.6}$$

Summing up:

The ordinary Heine series

$$x^{\rho - 1} \, _m\varphi_n \, (q^{a_1}, \ldots, q^{a_m}; q^{b_1}, \ldots, q^{b_n}; tx)$$

$$\supset_q \; s^{-\rho} \, (q; \rho - 1) \, _{m+1}\varphi_n \, (q^{a_1}, \ldots q^{a_m}, q^\rho \; ; q^{b_1} \ldots, q^{b_n}; t/s),$$

<div align="right">$m \leqslant n; \; |t| < |s| \, ; \rho > -1.$</div>

The k-confluent series

$$x^{\rho - 1} \, _{n-k}\Phi_{n-1} \, (q^{a_1} \ldots, q^{a_{n-k}}; b^{b_1}, \ldots, q^{b_{n-1}}; tx)$$

$$\supset_q \; s^{-\rho} \, (q; \rho - 1) \, _{n-k+1}\Phi_n \, (q^{a_1}, \ldots, q^{a_{n-k}}, q^\rho \; ; q^{b_1}, \ldots, b^{b_{n-1}}, 0; t/s),$$

<div align="right">$|t| < |s| \, ; \rho > -1.$</div>

The q-exponential functions

$$Eq \, (ax) \supset_q \; (1/s)_1\varphi_1 \, (q; 0; a/s), \quad |a| < |s|$$

$$e_q \, (ax) \supset_q \; 1/(s - a)$$

<div align="center">{ 407 }</div>

In conclusion it may be remarked that the Rules of the above transform discussed in this paper are particularly interesting from the point of view of application to q-difference and q-partial difference equations. This forms the subject-matter of a subsequent communication.

I am indebted to Dr. R. P. Agarwal for his unsparing help in the preparation of this paper and to Prof. Dr. W. Hahn for his valuable suggestions.

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ALLAHABAD

Dr. M. S. Randhawa
President of the Academy

THE

National Academy of Sciences, India

ANNUAL NUMBER

1960

THE THIRTIETH ANNUAL SESSION

By

ARUN K. DEY

Officer on Special Duty of the Academy

The Thirtieth Annual Session of the National Academy of Sciences, India, was held at Allahabad, at the invitation of the University on Feb. 3, 4 and 5, 1961. The inaugural session was held in the Vizianagram Hall of the Faculty of Science at 2.30 P.M. on the 3rd February, and was presided over by Dr. M. S. Randhawa, the President of the Academy. The session opened with the singing of Vande-Matram, followed by reading of messages by Prof. R. N. Tandon, the General Secretary. Prof. Shri Ranjan, Vice-Chancellor of the University of Allahabad and Chairman of the Reception Committee welcomed the delegates. In the welcome address, he briefly outlined the history of the starting of the Academy with its headquarters at Allahabad, and mentioned the association of Professors of this University with the growth and development of the Academy. He called upon the scientists assembled on the occasion to work for the betterment of the society.

Prof. S. N. Bose, F. R. S., National Professor, inaugurated the thirtieth session. In his extempore address, he recalled his old friendship with the late Prof. M. N. Saha, the Founder President of the Academy and paid tributes to his memory. His address mainly dealt with the methodology of research in more advanced countries and he pleaded for an improvement of the quality of research in our country. Dr. M. S. Randhawa, then delivered his presidential address on "Recent Advances in the Study of the Structure of the Chromosomes and Mechanism of Photosynthesis."

The Uttar Pradesh Education Minister's Gold Medal was presented to Dr. Amar Singh for his research papers on Botany, published in the proceedings of the Academy, during the period 1957-60.

The foreign delegates were introduced by Prof. B. N. Prasad. They were: Dr. David Cecil Rife, Deputy Science Attache, U. S. Embassy in India, and Mrs. Rife. Dr. Rife is a specialist in Genetics and was formerly a professor at Ohio State University. The U. S. S. R. Academy of Sciences was represented by Dr. A. T. Vagramyan of the Electro-Chemical Institute of the Academy at Moscow. Dr. Vagramyan is well known for his researches in electrochemistry.

Votes of thanks to the Chief Guest were offered by Profs. N. R. Dhar and P. S. Gill, and to the University of Allahabad by Drs. M. S. Randhawa and N. K. Sur.

The inaugural function closed with the National Anthem, after which a group-photograph was taken.

From the 4th Feb., the session split up into sections of Physical and Biological Sciences. The President of the Physical Sciences Section, Shri S. Basu, could not be present and his presidential address on "Tropical Storms" was briefly summarised by Prof. N. R. Dhar, who conducted the proceedings of the section. In this section fifty seven papers were presented for reading and discussion.

The section of Biological Sciences was presided over by Prof. M. D. L. Srivastava, who read his presidential address on "The Structure of the Chromosomes." Sixty three papers were presented in this section.

Symposia on "Ecological Problems in the Tropics", and "Spectroscopy" were held, in which a large number of scientists participated.

Three popular lectures were delivered by Prof. S. N. Bose (Future of Science Education), Prof. N. R. Dhar (Balanced Diet) and Dr. A. T. Vagramyan (Modern Techniques of Electrodeposition of Metals).

A number of social functions were arranged. The members and delegates were entertained to dinners and luncheons by the Scientific Instrument Company Ltd., by the Allottees Association of Naini Industrial Estate, Naini and by some citizens of Allahabad. The Vice-Chancellor of the University, the Director of Central Botanical Laboratory and the Members of the Reception Committee were At Home with the delegates and the members. Entertainment programmes were organised by the Music Department and the Delegacy Women's Association of the University.

The Academy records its grateful thanks to the Vice-Chancellor and other members of the Reception Committee and to all those who co-operated to make the session a success.

PROGRAMME

FRIDAY, 3rd February, 1961

2-30 p.m.   Annual Meeting (*Vizianagram Hall*)

    1.   Bande Mataram

    2.   Appointment of two scrutineers by the President to count votes

    3.   Reading of Messages by the General Secretary

    4.   Welcome Address by Prof. S. Ranjan, Vice-Chancellor, University of Allahabad and Chairman, Reception Committee

    5.   Annual Report by Prof. R. N. Tandon, General Secretary

    6.   Inaugural Address by Prof. S. N. Bose, F.R.S., National Professor

    7.   Presidential Address by Dr. M. S. Randhawa, President of the Academy

    8.   Presentation of Uttar Pradesh Education Minister's Gold Medal to Dr. Amar Singh

    9.   Introduction of Foreign Delegates by Prof. B. N. Prasad

    10.   Announcement of Office-Bearers for 1961

    11.   Vote of thanks to the Chief Guest by Prof. N. R. Dhar and Prof. P. S. Gill.

    12.   Vote of thanks to the University of Allahabad by Dr. M. S. Randhawa and Dr. N. K. Sur.

    13.   National Anthem

    Group-photograph of Distingulshed Guests, Members and Delegates

4-30 p. m.   "At Home" by the Vice-Chancellor, University of Allahabad (*M.C.C. Quadrangle*)

5-30 p. m.   Popular Lecture "Future of Science Education" by Professor S. N. Bose (*Physics Lecture Theatre*)

7 p. m.   Entertainments by University Music Department (*Vizianagram Hall*)

8 p. m.   Dinner by the Scientific Instrument Co. Ltd. (3, *T. B. Sapru Road*)

SATURDAY, 4th February, 1961

9-30 a. m.   Presidential Addresses (*Physics Lecture Theatre*)

      (*a*) Section of Physical Sciences "Tropical Storms" by Shri S. Basu

      (*b*) Section of Biological Sciences : "The Structure of the Chromosome" by Prof. M. D. L. Srivastava

10-30 a. m. to 12 noon   Sectional Meetings: Reading of Contributed Papers

      (*a*) Section of Physical Sciences (*Physics Lecture Theatre*)

      (*b*) Section of Biological Sciences (*Botany Lecture Theatre*)

1 p. m.   Lunch by The Allottees Association of Naini Industrial Estate (*Administrative Block, Industrial Estate, Naini*)

2-30 p. m.   Symposia :

      (*a*) Ecological Problems in the Tropics (*Botany Lecture Theatre*)

      (*b*) Spectroscopy (*Physics Lecture Theatre*)

5 p. m.   "At Home" by the Reception Committee (*M. C. C. Quadrangle*)

6 p. m.   Popular Lecture "Balanced Diet" by Prof. N. R. Dhar (*Physics Lecture Theatre*)

7 p. m.   Entertainments by University Delegacy Women's Association (*Dramatic Hall*)

8 p. m.   Dinner by Some Citizens of Allahabad (*Vizianagram Hall*)

SUNDAY, 5th February, 1961

9-30 a. m. to 1 p. m. Sectional Meetings and Symposia (II meeting)

1 p. m.   Lunch by the Reception Committee (*Vizianagram Hall*)

2 p. m. to 5 p. m.   Symposium on (*a*) Ecological Problems in the Tropics

      (*b*) Spectroscopy

5 p. m.   "At Home" by the Central Botanical Laboratory (10, *Chatham Lines*)

6 p. m.   Popular Lecture 'Modern Techniques for the Electrodeposition if Metals' by Dr. A. T. Vagramyan (*Chemistry Lecture Theatre*)

MESSAGES

Dr. S. RADHAKRISHNAN, Vice-President of India

I wish the Thirtieth Annual Session of the National Academy of Sciences all success. The Conference will no doubt encourage people to work hard and make valuable contributions to Scientific research.

Prime Minister of India

The Prime Minister sends his good wishes to the National Academy of Sciences on the occasion of its Thirtieth Annual Session.

Dr. B. RAMAKRISHNA RAO, Governor, U. P.

I am glad to know that the National Academy of Sciences is holding its Thirtieth Annual Session in the Allahabad University from February 3rd, 1961. This is the Age of Science and the work which the National Academy, the oldest Scientific Academy in India, has been doing since its inception for the advancement of science and the scientific research in our country, is most commendable. I am sure our great scientists through their researches will not only evolve methods which will change the face of our country from poverty to plenty but will also bring still more fame to our country in the scientific world. I extend a most cordial welcome to the scientists attending the session and wish it all success.

Shri SRI PRAKASA, Governor of Maharashtra

I am glad to learn that the National Academy of Sciences is holding its Thirtieth Annual Session at Allahabad in February 1961.

Science has been making astounding progress. Scientists have been tapping atomic energy which can do great good or harm depending upon the use to which it is put. New inventions with their fearful capacities for destruction, will doubtless cause a repulsion in the minds of men, and impel them to ask for a ban on scientific experiments.

A heavy responsibility, therefore, lies on the scientists to assure all concerned that they are working for the welfare of humanity, and not for its annihilation. I hope scientists and politicians alike will prove to the world by their actions, that it is really safe in their hands, and that by following the ways prescribed by them, it will truly progress and prosper.

I send my best wishes for the success of the session and all health and happiness to those participating in the same.

Prof. HUMAYUN KABIR, Minister, Scientific Research and Cultural Affairs, India

I am glad to learn that the National Academy of Sciences, India, is holding its Thirtieth Annual Session at Allahabad during the first week of February, 1961.

Scientific societies in India have a twofold function. They must serve as clearing houses where knowledge can be pooled and the latest developments in research brought to the knowledge of all workers in the field. They must also help to develop the scientific spirit with its emphasis on intellectual daring and humility and its recognition that in the world of science there must be freedom of enquiry and research based on equality of all workers, old and new.

The National Academy of Sciences, India, has served the cause of science during the last thirty years by publishing papers on physical and biological sciences and distinguished scientists have been associated with it since its inception. I send my good wishes for the success of the current session.

Dr. K. L. SHRIMALI, Education Minister, India

I am glad that the National Academy of Sciences, India, is celebrating its Thirtieth Annual Session. At this time when we are developing our sciences, the National Academy has a very important role to play in the promotion of sciences, I wish the Academy every success.

Dr. SAMPURNANAND, Former Chief Minister, U. P.

I am glad to learn that the National Academy of Sciences is holding its Thirtieth Annual Session in February next at Allahabad.

The present period is particularly favourable for the growth of science, and when I say this I do not mean only science in its practical and utilitarian aspect, but also in the higher regions of principles and theory, because the two are inextricably inter-linked and it is just not possible to neglect the latter without creating serious impediments in the way of scientific progress. I know that research workers are still denied full opportunities for research. This is mainly due to paucity of funds though lack of imagination is also an important contributory cause. But many pioneers in science have had to face such difficulties and the Indian Scientist must also blaze the trail, to some extent, in providing the equipment which he needs. If he does so, he will be trading a path which so many distinguished scientists have traversed before.

Science latterly has registered considerable progress and even at the moment considerable tempo and speed is being maintained, so much so that serious misgivings have arisen in certain minds about the possibility of dovetailing this knowledge with social ethics and moral obligations. Science has tamed nature and unleashed forces of considerable magnitude and one shudders to think what the result of this advance will be if this knowledge is not utilized properly. We are at present at the cross-roads. It is up to us to use this knowledge for annihilation of the world or for improving the lot of mankind and introducing a millennium, the like of which the world has not known before.

On this occasion I would like to send my best wishes to the Academy.

Dr. K. N. KATJU, Chief Minister, M. P.

It is now well-realised that the key to the future prosperity of the country lies in technological and scientific advancement. We are behind other nations because we are behind them in these fields. There is no dearth of resources or talents in India. We have only to provide opportunities to them. I have no doubt the National Academy of Sciences will give its particular attention to the questions of training of scientific and fundamental research, which are the foundations of all scientific advancement. It is only fitting that the Allahabad University with its long tradition of scholarship and academic achievements should play the host to this learned body for its 30th session. I extend my best wishes for its success.

Prof. N. R. DHAR, President, Indian Science Congress Association

That your Academy is completing thirty years of its fruitful existence to hold the 30th Annual Session from 3rd to the 5th February, 1961, is a piece of stimulating news for our Association which too stands for the identical cause as yours, viz., advancement of science in India. It is my sincere hope that with the holding of this particular session your organisation will step into another decade of growing activities that would eventually usher in a new era of development of science in India.

I express on behalf of this Association our hearty good wishes for an impressive success of your forthcoming session at Allahabad.

THIRTIETH ANNUAL SESSION
ALLAHABAD, February 3 to 5, 1961
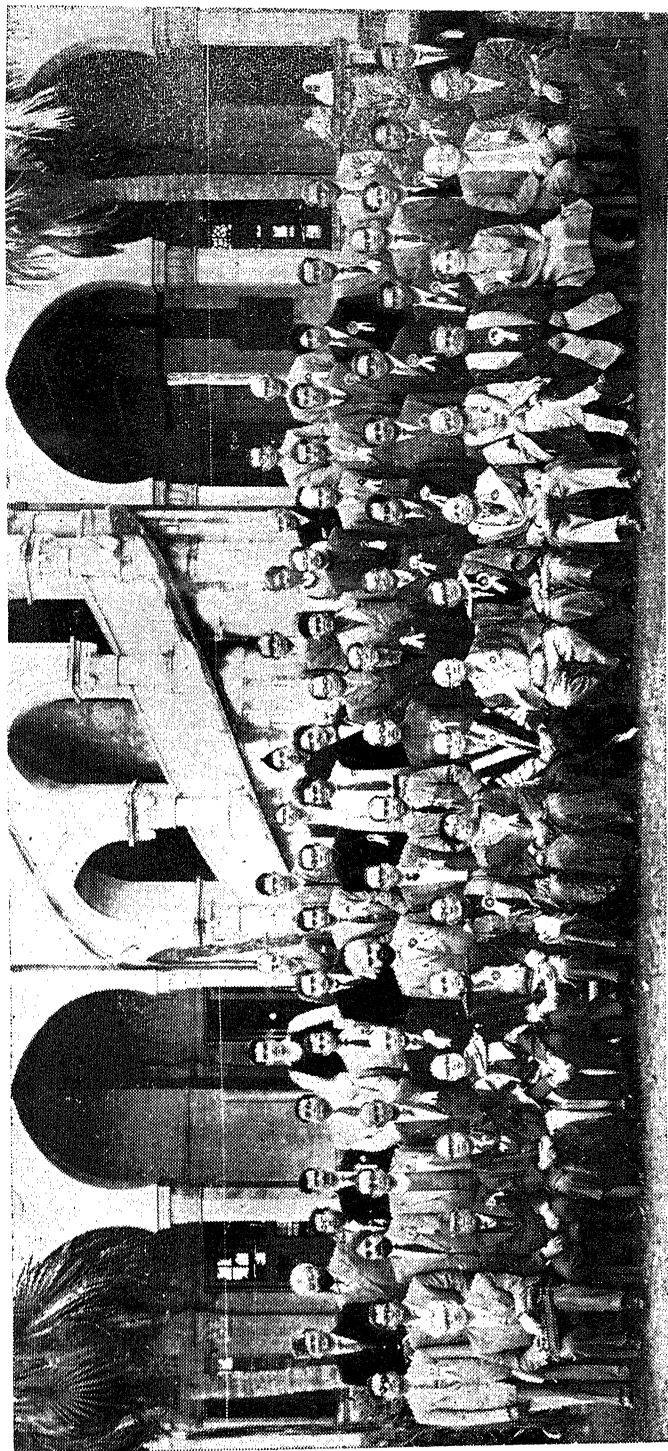
Sitting 1st Row (L. to R.): Dr. A. T. Vagramyan, Prof. A. C. Chatterji, Prof. B. N. Prasad, Prof. R. N. Tandon, Prof. P. S. Gill, Prof. N. R. Dhar, Prof. S. N. Bose, Prof. Shri Ranjan, Dr. M. S. Randhawa, Prof. S. Ghosh, Prof. M. D. L. Srivastava, Prof. P. L. Srivastava, Dr. R. K. Saksena, Mrs. D. C. Rife, Dr. D. C. Rife, Dr. V. M. Vaidya.

Standing 1st Row (L. to R.): Dr. S. R. Sinha, Dr. K. Laxminarayanan, S. Dayal Singh, Dr. R. P. Patil, Dr. W. K. Wesley, Dr. K. D. Vyas, Dr. G. S. Puri, Sri S. K. Jain, Dr. S. P. Mushran, Sri G. D. Srivastava, Dr. U. N. Chatterji, Dr. A. K. Mittra, Dr. M. P. Tandon, Dr. B. B. L. Saxena, Dr. A. K. Dey, Dr. U. S. Srivastava, Dr. B. S. Mehrotra, Dr. J. K. Chaudhari, Dr. Amar Singh, Prof. N. L. Singh.

Standing 2nd Row (L. to R.): Lt. Col. S. S. Kambargimath, Maj Gujrel, Sri S. N. Bhargava, Sri O. N. Bhardwaj, Dr. M. P. Singh, Sri Dinesh Kumar, Sri V. P. Agnihotri, ..., Dr. D. B. Saksena, Dr. K. S. Bilgrami, Dr. M. M. Laloriya, Prof. S. N. Ghosh, Sri Jamuna Prasad, Dr. O. N. Perti, Dr. S. P. Srivastava, Dr. Y. K. Gupta, Dr. S. G. Misra, Sri S. S. Uppal, Dr. K. C. Bose, Dr. L. N. Jauhari.

Standing 3rd Row (L. to R.): Sri Lakshmi Kant Tewari, Sri B. K. Mukerji, Sri Sharda Prasad, Sri Sakhan Lal, Sri Nanku Ram, Dr. K. Majumdar, Sri B. S. Rao, Dr. G. B. Deodhar, Dr. P. D. Pathak, Dr. J. S. Dave.

WELCOME ADDRESS

By

Professor SHRI RANJAN, D.Sc., F.N.I., F.A.Sc., F.N.A.Sc.

Vice-Chancellor, University of Allahabad

and

Chairman, Reception Committee

MR. PRESIDENT, PROFESSOR BOSE, MEMBERS OF THE ACADEMY, LADIES AND GENTLEMEN,

On behalf of the University of Allahabad and myself, I have the privilege of extending to you a cordial and warm welcome to the thirtieth annual session of the National Academy of Sciences, India. I am glad that the authorities of the Academy have kindly accepted the invitation of the university to hold the annual session at Allahabad. As you are aware, the Academy had been founded with its headquarters here in 1930 by scientists from various parts of the country and the late Prof. M. N. Saha, F. R. S., the Founder President was then occupying the Professorial chair in Physics of this University. The Academy was housed in the campus of the University till 1953, when, from funds raised by your President, Dr. M. S. Randhawa, it built a home for itself on a piece of land donated by Prof. N. R. Dhar, who is also from this university. Thus the university has been closely associated with the growth and development of the National Academy of Sciences, India.

It is a matter of special gratification for me personally, to welcome you here, as I was connected with the Academy since its inception in various capacities. I recall with pleasure that I had the privilege of being the General Secretary during the period 1939-42 and the honour to occupy the Presidential chair of the Academy during 1955 and 1956. Thus it gives me pleasure to be amidst my own colleagues and to welcome them here, and I wish them a very successful session.

The Academy is fortunate to have Prof. S. N. Bose, F. R. S. to inaugurate the session at Allahabad. Prof. Bose has been a close associate of our first President Prof. M. N. Saha and it is in the fitness of things that he is amongst us, when the Academy is holding its session at its own birth place.

Allahabad, as you well know, is an ancient city, and has been a seat of learning from the earliest times. The ancient Ashram of Rishi Bharadwaj was situated near the present University campus, where thousands of disciples had their instruction in scriptures and various branches of learning. The city continued to be associated with academic activities through the ages and with the advent of British rule in India, the present university was established in 1887, and had to perform the great responsibility of taking care of the higher education of a vast portion of the country comprising Northern and Central India. As a result of the achievements of the University towards the promotion of higher education, a number of institutions originally fostered by this University grew in importance and stature and ultimately served as nuclei or helped towards the establishment of new Universities.

Allahabad has been the pioneer for starting scientific research in northern India. The pursuit of scientific research in the University was intensified by the reorganisation of the University in 1927 when it assumed the pattern of a residential character. The laboratories in the faculty of Science are well known in the

scientific world for their contributions to various branches of physical and biological sciences.

During the first two plan periods in the post-independence era, special strides have been made in the qualitative and quantitative expansion of scientific research and the university has been contributing to the increase of scientific manpower in this country.

The University has an ambitious plan of expansion during the Third Five Year Plan with the addition of two new faculties, *viz.*, those of Engineering and Medicine. We recently celebrated the seventieth anniversary of the university and donations received on the occasion will help us in furthering our plans and in strengthening the spread of scientific education in the country.

It is said that the first academy was a pleasure garden in Athens which originally belonged to an ancient Attic hero named Academus. It was in this garden that the Greek philosopher Plato held his learned discourses. The place came to be known as the Academy and gradually the term was applied to institutions where teaching and discussions could be held in an atmosphere of peace and solitude. Thus, in ancient India also, the Ashrams of the Rishis were usually located at places away from the noise and bustle of urban life.

The closing years of the last century and the beginning of the present century saw the birth of researches in experimental sciences in this country and a necessity was felt of having a common platform where the workers of science could meet and exchange notes. Thus the Asiatic Society of Bengal started in 1746, which was concerned with all branches of knowledge was considered inadequate for the scientists and the Indian Science Congress was founded in 1914. Soon after, a number of societies devoted to specialised branches of science came into being.

However, there were no scientific academies, where workers of various scientific disciplines could occasionally meet and discuss their achievements. Our Academy was established in 1930 to meet this requirement. Three years later, the Indian Academy of Sciences was started with its headquarters at Bangalore. The two academies and Asiatic Society of Bengal, having their headquarters in different regions of the country were regarded as regional organisations despite their all-India membership and status. The National Institute of Sciences was founded in 1935 to secure close liaison between the scientific academies and is also regarded by the government as an advisory body in regard to scientific matters.

Today science forms the foundation of human progress and civilization. Thus, in our country, we need the output of a large number of scientists who would be needed to dedicate themselves to the cause of the prosperity of the country. In the pre-independence era, the functions of the scientific societies were more or less those of debating societies on an intellectual level. Today, the academies have a greater role to play. They must direct their activities towards the mobilization of scientific talents and their work for the betterment of the society. Scientific research has to be tackled in relation to the development of the nation, and for its effective use in terms of industry, defence and communications.

May I request the scientists assembled here to direct their endeavours to this end and offer their co-operation towards a better and prosperous India?

Ladies and gentlemen, I once again offer you a most cordial welcome to this seat of learning and hope that you will forgive us for any shortcomings. I wish you to have a happy stay at Allahabad and a fruitful academic session.

A view of the dais.

A view of the audience.

Prof. R. N. Tandon reading the Secretaries' Report.

Prof. N. R. Dhar moving a vote of thanks.

SECRETARIES' REPORT

Presented at the Thirtieth Annual Session of the Academy on the 3rd February 1961 at the University of Allahabad.

By

Professor R. N. TANDON, M.Sc., Ph.D. (London), D.I.C., F.A.Sc., F.N.A.Sc.

On behalf of the General Secretaries, I have pleasure in submitting the following report on the working of the Academy during the period 1st January 1960 to 31st December 1960.

MEMBERS

The Academy had on its rolls 278 members in good standing of whom 119 were Fellows.

The following new members have been elected during the year and we take the opportunity to welcome them :

1. Sri B. D. Bhatia, B.V.Sc. and A. H., Demonstrator, U. P. College of Veterinary Science and Animal Husbandry, Mathura.

2. Dr. (Kumari) Uma Agarwal, M.Sc., D.Phil., Research Assistant, Central Drug Research Institute, Chattarmanzil Palace, Lucknow.

3. Dr. A. N. Tandon, M.Sc., D.Phil., Seismologist, Meteorological Office, Lodi Road, New Delhi.

4. Sri B. D. Bhatt, M.Sc., Lecturer in Zoology, St. Andrew's College, Gorakhpur.

5. Dr. Jatashanker Sadashiv Dave, M.Sc., Ph.D., A.R.I.C., Reader in Physical and Inorganic Chemistry, Faculty of Science, M. S. University, Baroda.

6. Sri Ram Babu Malviya, M.Sc., Lecturer in Zoology, Mahakoshal Mahavidyalaya, Jabalpur.

7. Dr. T. N. Khoshoo, M.Sc., Ph.D., Senior Lecturer, Botany Department, Punjab University, Khalsa College, Amritsar.

8. Sri Rajeshwar Kumar Arora, M.Sc., Asst. Ecologist, Botanical Survey of India, 43, Lansdowne Road, Calcutta-30.

9. Dr. R. S. Mishra, M.Sc., Ph.D., D.Sc., F.N.I., Professor of Mathematics, University of Gorakhpur, Gorakhpur.

10. Dr. H. D. Srivastava, M.Sc., D.Sc., Head of the Division of Parasitology, Indian Veterinary Research Institute, Izatnagar.

11. Sri Bhopindra Singh Ahuja, M.Sc., Junior Research Fellow, Botanical Survey of India, Western Circle, Poona-1.

12. Sri G. Lakshminarayana, M.A., Lecturer in Mathematics, University College of Science, Osmania University, Hyderabad.

13. Sri Suresh Behari Mathur, M.Sc., Research Scholar, Botany Department, Agra College, Agra.

14. Prof. G. C. Shivahare, M.Sc., Head of the Chemistry Department, Maharaja's College, Jaipur.

15. Dr. K. N. Trehan, M.Sc., Ph.D. (London), Senior Lecturer and Officer-in-Charge of I. C. A. R. Scheme, Zoology Dept., Hoshiarpur.

16. Sri C. P. Malhotra, M.Sc., Instructor, Indian Lac Research Institute, Nankum, Ranchi (Bihar).

17. Dr. P. N. Keshav, M.Sc., Ph.D., Head of the Building Material Division, Central Building Research Institute, Roorkee.

18. Dr. Eric John Singh, M.Sc., D.Phil., Research Fellow, Chemistry Department, University of Allahabad, Allahabad.

19. Dr. S. K. Roy, M.Sc., Ph.D., Assistant Professor of Botany, University of Gorakhpur, Gorakhpur.

20. Dr. K. C. Basu Chaudhary, M.Sc., Ph.D., Associate Professor of Botany, Botany Department, Agra College, Agra.

21. Dr. Daya Prasad Khandelwala, M.Sc., Ph.D., Professor of Physics, D. S. B. Government College, Nainital.

22. Sri Hari Datt Pathak, M.Sc., Asst. Professor of Chemistry, D. S. B. Government College, Nainital.

23. Sri S. N. Singh, M.Sc., Palaeontologist, Oil and Natural Gas Commission, 19, Rajpur Road, Dehra Dun.

24. Sri Vishnu Shankar Patel, M.Sc., Lecturer in Chemistry, J. H. Govt. Degree College, Betul (M. P.).

25. Dr. Devi Ram Gupta, M.Sc., Ph.D., Asst. Professor of Chemistry, D. S. B. Government College, Nainital.

26. Sri Udai Pal Singh Chhonker, M.Sc., Asst. Professor of Botany, D. S. B. Government College, Nainital.

27. Dr. S. P. Bhatnagar, M.Sc., Ph.D., Professor of Zoology, D. S. B. Govt. College, Nainital.

28. Dr. S. N. Bhardwaj, M.Sc., Ph.D., Botany Department, Agra College, Agra.

29. Sri Tarkeshwar Singh, M.Sc., Research Scholar, Mathematics Department, University of Allahabad, Allahabad.

30. Sri Munendra Nath Gupta, M.Sc., Asst. Professor of Botany, Agra College, Agra.

31. Sri A. P. Bhattacharya, M.A., Research Officer, Basic Research Division, Irrigation Research Institute, Roorkee.

32. Dr. V. P. Agarwal, M.Sc., Ph.D., Head of the Zoology Department, D. A. V. College, Muzaffarnagar.

33. Sri Ravindra Pratap Rao, M.Sc., Asst. Professor of Chemistry, University of Gorakhpur, Gorakhpur.

34. Sri Wazir Aasan Abdi, M.A., Research Scholar, Department of Mathematics University of Lucknow, Lucknow.

35. Sri O. N. Bhardwaj, M.Sc., Research Scholar, Zoology Department, Mahakoshal Mahavidyalaya, Jabalpur.

36. Dr. M. N. Sarin, M.Sc., Ph.D., Botany Department, Agra College, Agra.

37. Dr. S. K. Chauhan, M.Sc., Ph.D., Lecturer in Botany, Agra College, Agra.

38. Dr. A. S. Dwivedi, M.Sc., Ph.D., Asst. Professor of Zoology, Th. D. S. B. Government College, Nainital.

39. Sri K. M. Rao, M.A., Lecturer, Government Mining Institute, Kothagudem.

40. Sri R. C. Nigam, M.Sc., B.Sc., (Hons.), Inspector of Factories, U. P., Kanpur.

41. Dr. C. M. Singh, M.Sc., Ph.D., Professor of Pathology and Bacteriology, U. P. College of Veterinary Science and Animal Husbandry, Mathura.

42. Sri Kuldip Singh Bachher, M.Sc., Research Scholar, Central Botanical Laboratory, 10, Chatham Lines, Allahabad.

43. Sri Krishna Gopal Mithal, M.Sc., Research Scholar, Mathematics Department, University of Lucknow, Lucknow.

44. Sri Amar Nath Gupta, M.Sc., Asst. Professor of Zoology, K. N. Govt. Degree College, Gyanpur, Varanasi.

45. Dr. S. N. Rao, M.Sc., Ph.D., F.R.E.S., F.A.Z., Head of the Zoology Department, Madhav College, Ujjain.

46. Sri C. S. Singh, M.Sc., Research Scholar, Botany Department, Banaras Hindu University, Varanasi-5.

47. Dr. C. J. Dominic, M.Sc., Ph.D., Lecturer in Zoology, Banaras Hindu University, Varanasi-5.

48. Sri M. S. Bhadraver, M.Sc., Head of the Chemistry Department, Lohia College, Churu.

49. Dr. B. M. Sinha, M.Sc., Ph.D., Professor of Zoology, Meerut College, Meerut.

50. Sri Jagdish Chandra, M.A., Lecturer in Mathematics, S. V. University, Tirupathi (A.P.).

51. Dr. S. K. De, B.Sc., (Ag.), M.Sc. (Ag. Bot.), M.Sc. (Ag. Chem.), D.Phil., Asst. Professor of Chemistry, University of Allahabad, Allahabad.

52. Dr. R. P. Patil, B.A., (Hon.), M.Sc., (Bombay), Ph.D., Botanist, Central Botanical Laboratory, 10, Chatham Lines, Allahabad.

53. Dr. K. D. Kaushic, M.A., Ph.D., Professor and Head of the Geography Department, S. S. V. College, Hapur.

54. Dr. Balwant Singh, D.Sc., F.R.I.C., P.E.S.I., (Retd.) Reader in Inorganic Chemistry, Punjab University, Chandigarh-3.

55. Prof. Ram Chard Paul, M.Sc., Ph.D., F.R.I.C., Head of the Chemistry Department, Punjab University, Chandigarh-3.

56. Dr. B. R. Puri, M.Sc., Ph.D., Reader in Physical Chemistry, Punjab University, Chandigarh-3.

57. Sri S. L. Rai, M.Sc., Research Scholar, Department of Zoology, Mahakoshal Mahavidyalaya, Jabalpur.

58. Sri Sudhir Chandra, M.Sc., Research Scholar, Botany Department, University of Allahabad, Allahabad.

59. Dr. J. S. P. Yadav, M.Sc., (Ag.) Ph.D., I.A.R.I., F.G.S., Soil Chemist, Forest Research Institute, P. O. New Forest, Dehra Dun.

60. Dr. J. D. Sampath Kumaran, Ph.D., (U.S.A.), M.A., B.S.A., L.V.P., F.R.N.S., Professor and Head of the Department of Physiology and Biochemistry, Baghdad University, College of Veterinary Medicine, Baghdad (Iraq).

61. Dr. B. B. Sharma, B.Sc., (Hons.), M.Sc., Ph.D., F.B.S., Asst. Professor of Botany, University of Lucknow, Lucknow.

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FELLOWS

We have pleasure to announce the election of the following to the Fellow-ship of the Academy :

1. Prof. A. K. Bhattacharya, D.Sc., F.R.I.C., Head of the Chemistry Department, Agra College, Agra.
2. Prof. K. S. Bhargava, M.Sc., D.Phil., Ph.D., Head of the Botany Department, University of Gorakhpur, Gorakhpur.
3. Dr. B. Chakravarti, M.Sc., D.Phil., Asst. Project Officer, Sindri Fertili-zers and Chemicals (Private) Ltd., Sindri Dhanbad.
4. Dr. B. S. Chauhan, Ph.D., D.Sc., F.Z.S., F.A.Sc., Asst. Superintendent, Zoological Survey of India, 34, Chittaranjan Avenue, Calcutta-12.
5. Dr. J. S. Dave, M.Sc., Ph.D. A.R.I.C., Reader in Inorganic and Physical Chemistry, Faculty of Science, M.S. University, Baroda
6. Prof. R. S. Mishra, M.Sc., Ph.D., D.Sc., F.N.I., Head of Mathematics Department, University of Gorakhpur, Gorakhpur.
7. Dr. G. S. Puri, M.Sc., Ph.D., F.L.S., F.G.S., Director, Central Botanical Laboratory, 10, Chatham Lines, Allahabad.
8. Dr. B. Ramamoorthy, M.S., D.Phil., Assoc. I.A.R.I , Physical Chemist, Division of Chemistry, Indian Agricultural Research Institute, New Delhi-12.
9. Prof. D. P. Sadhu, M.Sc., Ph.D., Professor and Head of the Department of Physiology and Nutrition, Bengal Veterinary College, Calcutta.
10. Dr. B. N. Singh, M.Sc., D.Sc., Ph.D., Asst. Director (Microbiology), Central Drug Research Institute, Lucknow.

OBITUARIES

We regret to announce the death of the following members of the Academy during the year :—

1. Dr. S. P. Mitra,
2. Prof. B. K. Singh,
3. Dr. H. M. Sen Gupta.

MEETINGS

During the year under review 8 meetings of the Council, 8 meetings of the General Body and 2 meetings of the Fellows were held. Besides the transaction of business, papers were read and discussed at the ordinary meetings.

ANNUAL SESSION

The Twenty-ninth annual session was held at Gorakhpur on February 7, 8 and 9, 1960 at the invitation of the Gorakhpur University. Hon'ble Sri Mohan Lal Gautam, Minister of Agriculture, U. P., had kindly inaugurated the session.

In the absence of the President Dr. M. S. Randhawa, the senior member Prof. P. L. Srivastava took the chair. The session was attended by nearly one hundred delegates from different parts of the country. The section of Physical Sciences was presided over by Prof. B. N. Prasad where 23 papers were presented. The Section of Biological Sciences was presided over by Prof. P. N. Mehra, where 49 papers were presented.

A symposium on Nitrogen Problem was held under the presidentship of Professor N. R. Dhar, Director, Sheila Dhar Institute of Soil Science, University of Allahabad. The symposium was a great success and aroused keen interest all over the scientific world. Nearly sixty papers were received from important laporatories of the country and abroad.

Popular lectures were delivered by Professor N. R. Dhar and Professor D. Sharma.

The Uttar Pradesh Education Minister's, Gold Medal for 1959 was awarded to Dr. R. S. Kushwaha for the best research work in Mathematics and Astronomy published in the Proceedings of the Academy during 1954-59.

Besides the academic programme, Excursions to Kushinagar and Sardarnagar were organised.

The Academy expresses its gratitude to Sri B. N. Jha, Vice-Chancellor, Gorakhpur University, to Dr. R. C. Mehrotra, Local Secretary and to his able colleagues of the University for the success of the session.

COUNCIL

The following constituted the Council of the Academy during 1960.

President

1. Dr. M. S. Randhawa, M.Sc., D.Sc., F.N.I., F.N.A.Sc., I.C.S., New Delhi.

Vice-Presidents

2. Prof. K. Banerjee, D.Sc., F.N.I., F.N.A.Sc., Allahabad.
3. Prof. P. S. Gill, M.S., Ph.D., F.A.P.S., F.N.I., F.N.A.Sc., Aligarh.

Honorary Treasurer

4. Prof. S. Ghosh, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Allahabad.

Foreign Secretary

5. Prof. B. N. Prasad, Ph.D., D.Sc., F.N.I., F.N.A.Sc., Allahabad.

General Secretaries

6. Prof. R. N. Tandon, M.Sc., Ph.D., D.I.C., F.A.Sc., F.N.A.Sc., Allahabad.
7. Dr. K. N. Mathur, D.Sc., F. Inst. P., F.N.A.Sc., New Delhi.

Members

8. Prof. N. R. Dhar, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., Allahabad.
9. Prof. A. K. Bhattacharya, D.Sc., F.R.I.C., F.N.A.Sc., Sagar.
10. Prof. S. Ranjan, M.Sc., D.Sc., F.N.I., F.N.A.Sc., Allahabad.
11. D.. K. S. Krishnan, D.Sc., F.R.S, F.N.I., F.N.A.Sc., New Delhi.
12. Prof. P. L. Srivastava, M.A., D.Phil., F.N.I., F.N.A.Sc., Allahabad.
13. Dr. L. A. Ramdas, M.A., Ph.D., F.N.I., F.N.A.Sc., New Delhi.
14. Prof. M. D. L. Srivastava, D.Sc., F.N.A.Sc., Allahabad.
15. Dr. S. H. Zaheer, M.A., Dr. Phil. Nat., Hyderabad (Dn.)
16. Dr. A. C. Joshi, D. Sc., F.N.I., F.N.A.Sc., Solan.

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REPRESENTATIONS ON OTHER ORGANISATIONS

The Academy was represented by the following members on other organizations and conferences :—

1. Prof. S. Ghosh, Additional Vice-President, National Institute of Sciences of India.

2. Prof. P. L. Srivastava, Additional Member, Council of National Institute of Science of India.

3. Prof. N. R. Dhar, Member of the Indian National Commission for Cooperation with UNESCO.

FINANCES

The financial position of the Academy is given in the Financial Statement for 1959-60 ending on the 31st March 1960.

The Academy is thankful to :—

1. Government of India.
2. Government of Uttar Pradesh.
3. Government of Madhya Pradesh.
4. The National Institute of Sciences of India, and
5. The University of Allahabad.

for the assistance received from them.

The Academy, however, continues to work under great financial handicaps. We are unable to improve upon the publications for lack of funds. The office of the Academy needs to be reorganized and more staff is required for the smooth and proper execution of the objectives for which the Academy stands.

We hope that the Government and the Universities will come forward with enhanced grants in the present year to enable the Academy to perform its task more usefully.

PUBLICATIONS

Due to difficulty in regular supply of paper, the Council was forced to reduce the number of parts of its Proceedings from 12 to 8 (four parts of A series and four parts of B series). It was, however, decided to increase the number of pages of each part so that the total size of each volume may not be changed. Only one part of A series is in arrears and we hope to bring it uptodate very soon. The Annual Number of 1960 has also been published.

Our proceedings have been receiving recognition in the scientific world and we also have some foreign subscribers on our list. We have supplied sets of back issues to some foreign libraries. Much more has yet to be accomplished and improvement both in quantity and quality of the papers in the Proceedings is called for. The publication of monographs on special subjects has also been on our programme for several years. All these require money and we cannot implement these unless we receive greater encouragement in the form of grants.

EXCHANGE OF PERIODICALS

Inspite of the great demand for the exchange of our journal we are unable to entertain proposals for this purpose on account of paucity of funds and of staff to handle the work.

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The library of our Academy is rich in periodicals covering various branches of physical and biological sciences. The library, however, needs proper arrangements for stocking of periodicals and books. The Academy has been approaching the Union and State Governments for suitable grants to improve the library but we have not yet been able to get finances for this purpose. The need of a library in modern scientific pursuit need not be emphasized and we have every hope that in the near future grants would be forthcoming for the proper maintenance and improvement of our library. This year we have appointed an Assistant to catalogue the various journals received by us in exchange but our funds may not permit us to retain his services. It is earnestly requested that funds be made available for this purpose.

AWARD OF U. P. GOVERNMENT EDUCATION MINISTER'S GOLD MEDAL FOR 1960

We have great pleasure to announce that the Uttar Pradesh Government Education Minister's Gold Medal for 1960 for the best research work on Botany, Agriculture and Geology published in the Proceedings of the Academy during 1959-60 has been awarded to Dr. Amar Singh, M.Sc., D.Phil., F.N.A.Sc., Assistant Professor of Botany, University of Allahabad, on the recommendation of the judges.

GENERAL OBSERVATIONS

The Academy has completed three decades of its existence this year and is the oldest Scientific Academy in this country. It has on its rolls representatives from every part of this country and from every branch of scintific ativity. Many foreign scientists and some of our statesmen have honoured us by accepting the honorary Fellowships of the Academy. The Academy has always kept its doors open to scientific workers and welcomes them to become its members. It is our fervent hope that we shall have all scientific workers of the country on our rolls who will further the cause of sience by their co-operation in our activities.

The Academy has built a small home for itself but the area so far covered is a small fraction of the total plan. The building constructed has entirely been due to the efforts of its members without any aid from the Government. The Academy has been serving the cause of science in the country and expects help from all quarters for fulfilling the aims for which it was founded.

I am afraid that this report has become a catalogue of our wants, which shows clearly the heavy odds under which we have been functioning. We earnestly hope that the generous public, Universities and the Government will come forward with financial help and encourage the scientists to play an effective role in the service of the society.

ACKNOWLEDGMENTS

We acknowledge with thanks of the co-operation received from the referees of papers, the scruitinizers of voting papers, the judges for assessing the papers for the award of the Education Minister's Gold Medal, the Members of the Academy and the office staff for their help throughout the period under report.

FINANCIAL STATEMENT FOR THE YEAR 1959-60

INCOME		EXPENDITURE	

INCOME	Rs.
1. Opening Balance ...	7,832.26
2. U. P. Govt. Recurring grant for 1959-60 ...	6,000.00
3. Govt. of India non-recurring grant for 1959-60 ...	5,000.00
4. Allahabad University Grant for 1959-60 ...	1,000.00
5. Grant from the National Institute of Sciences of India, New Delhi ...	4,000.00
6. Grant from Govt. Madhya Pradesh for maintenance of a branch of this Academy at Saugar (M. P.) ...	4,500.00
7. Membership Subscription ...	2,647.00
8. Life Membership Subscription ...	3,825.02
9. Sale of Proceedings ...	2,997.71
	+ Dollars 68.37
10. Cost of Reprints ...	729.75
11. Bank Commission ...	16.62
12. Donation to Buildings	28.88
13. Transfer from the General account of the Saugar Branch	449.44
14. Transfer from the General account of the Annual Session ..	3.81
15. Refund of the balance of T. A. Advance ...	21.50
16. Cost of Telephone call ...	1.11
17. Loan realised from Sakhan Lal Chowkidar ...	3.00
18. Cost of Postage for sending Proceedings ...	4.88
19. Transfer from the Reserve Fund	8,000.00
20. Received back the uncashed cheque from Bradma of India Private Ltd. ...	54.44
Total ...	47,115.42
+ Dollars	68.37

This year a sum of Rs. 8000/- has been taken from the Reserve Fund to meet the urgent demand of the Presses towards expenditure on publication of journals but only a sum of Rs. 5,000/- could be retransferred to that fund. Thus a sum of Rs. 3,000/- still remain to be paid back to the Reserve Fund. Besides bills amounting to Rs. 2,672.77 are still outstanding from the Bangalore Press. These amounts could not be paid for lack of funds. Hence the Academy has in fact a deficit balance of Rs. 4,048.10.

EXPENDITURE		Rs.
Recurring		
1. Establishment ...		4,359.07
2. Dearness Allowance ...		1,129.68
3. Provident Fund Contribution ...		215.27
4. Postage ...		1,494.63
5. Printing and Stationary ...		301.69
6. Travelling Allowance ..		28.28
7. Annual Session ...		1,223.94
8. Gold Medal ..		145.00
9. *Transfer to Reserve und* —		
(a) Life membership fee as against item No. 7		3,825.02
(b) Refund of the part of the amount transferred from reserve fund as against item No. 19 ...		5,000.00
(c) Refund of the balance of the amount transferred from the Reserve fund as explained in the Financial statement for the year 1957-58 ...		1,631.50
10. *Cost of Publication of Journals* :—		
(a) Mission Press	Rs. 8,524.82	
(b) Capital Press	Rs. 1,070.00	
(c) Bangalore Press	Rs. 2,356.33	
(d) Cost of Printing Paper	Rs. 3,074.90	
(e) Cost of other paper	Rs. 250.57	
(f) Railway freight	Rs. 128.68	15,405.30
11. Expenses relating to holding Symposium :—		
(a) Publication charges	7,721.22	
(b) T. A. to participants	684.21	8,405.43
Non-recurring		
12. Bank charges ...		57.37
13. Audit fee ...		150.00
14. Transfer to Saugar Branch of the National Academy of Science, India, Saugar		900.00
15. Loan Advanced to Sri Sakhan Lal Chowkidar ...		18.00
16. Cost of Building Repairs ...		259.65
17. Transfer to Building fund ...		28.88
18. Contingencies ...		912.04
19. Cash in Hand ..		3.07
20. Bank Balance as per Cash Book		1,621.60
		+ Dollars 68.37
Total ...		47,115.42
		+ Dollars 68.37

Examined with the books and vouchers, certified correct to the best of our knowledge, information and belief.

Dated August 16, 1960

(Sd.) G. P. JAISWAL
for G. P. JAISWAL & Co.
Chartered Accountants

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Prof. S. N. Bose delivering the Inaugural Address.

Dr. M. S. Randhawa delivering the Presidential Address.

Dr. Shri Ranjan welcoming the delegates.

PRESIDENTIAL ADDRESS

RECENT ADVANCES IN THE STUDY OF THE STRUCTURE OF CHROMOSOMES AND MECHANISM OF PHOTOSYNTHESIS

By

Dr. M. S. RANDHAWA, D.Sc., F.N.I., F.N.A.Sc., I.C.S.

Vice-President, Indian Council of Agricultural Research, New Delhi

FELLOWS AND MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES, LADIES AND GENTLEMEN :

It is my privilege to address you on the occasion of the Thirtieth Annual Session of the National Academy of Sciences, India. It is indeed gratifying to learn that the Academy is making steady progress in many directions as just now indicated to you by the report of the Secretaries. I have every hope that in the years to come, the academy will continue to serve the cause of science, with the co-operation of you all. I am thankful to you for the honour done to me by electing me the President of the Academy.

In this address I propose to deal with the recent advances in the study of the structure of chromosomes and the process and mechanism of Photosynthesis. Both these problems are of fundamental importance in Biology, and in their understanding lies the key to the future of mankind on this planet. Biological sciences are just emerging from the preliminary stages of application of scientific method involving collection, description, classification, and observation of the outer and inner structure of plants and animals. Modern physics has provided delicate instruments to the biologist such as ultra-centrifuge, electron-microscope, spectrometer, etc. With the development of these instruments and their application in Biology, time is ripe for an accelerated and deeper attack upon the life sciences as observed by Dr. Warren Weaver.

One feels the same as Alice did in her Wonderland when one begins to survey all that has happened in the field of Biology in recent decades. The units of measurement which we use provide an immediate indication of the distance we have traversed in our quest to understand basic life processes. Starting from the simple microscopes of Leewenhoek and Robert Hooke which raised our observational powers from the level of the millimeter to that of the micron, we have reached the stage of the electron microscope which can resolve structures about 8 Angstroms apart ($1 \text{ Å} = \frac{1}{10,000}$ micron). Thus, visibility has been brought almost to the molecular level and it has become possible to correlate form and function. It is hard to believe now that in the 1920's it was generally accepted that no further improvements in microscopic observation could be expected. A simple conclusion of the famous Physicist Dirac, that particle streams could have wave properties, has opened completely new horizons in Biology. Advances in the field of electron diffraction, spectrophotometry chromatography and radio-tracer methodology have all had a profound influence on our understanding of the organisation, function and growth of the cell — the basic unit of life and I would like to refer briefly to a few of these developments.

Genes, Chromosomes and Molecular Biology :

The average person who looks at the world around himself is apt to be impressed more with the diversity than with the unity of life. Plants seem so different from animals. Algae seem so different from higher plants. The millions of different species of animals and plants, the range from viruses to man, from the microscopic alga to the giant Deodar tree, are evidence of the ability of protoplasm to take on myriad forms and to adopt multitudinous variations of structure without losing that structural key which makes it alive. Truly, the diversity of living material is a profoundly impressive fact. Yet, it is also a fact that all through this diversity there runs a unity of structure and function that is most amazing. Most of this unity reveals itself at the cellular level and all organisms, plant or animal, mouse or man, follow the same laws of heredity propounded by Gregor Mendel over a century ago and rediscovered in the early years of this century. The units of inheritance or genes are known to have their location on chromosomes in all organisms. The pattern of chromosome division in somatic and gametic cells has the same sequence in most plants and animals. Also, practically all cells in all organisms have mitochondria and associated with these are to be found the same respiratory enzymes and the same complicated chemical cycles by which energy is liberated. Even chlorophyll which seems to be such a distinctive and unique feature of green plants is structurally very closely related to the haeme molecule which forms the coloured part of the haemoglobin of the animal blood system. Thus, when one descends to the cellular level most of the differences which distinguish one class of organism from another disappear and there remains a common core of essential structure and function which appears to have been developed very early in the evolution of life.

Now that it has been established that the genes carried in the chromosomes are responsible for the determination of hereditary characters, it should be possible to analyze the chromatin chemically and so gain some idea of the molecular basis of heredity. Such research has been carried out and it appears that chromatin resolves itself into four major molecules: histone, a protein with low molecular weight, a more complex protein, deoxyribose nucleic acid (DNA) and ribose nucleic acid (RNA). These four molecules together form chromatin but results from several types of investivation have revealed that DNA is the key molecule whose structure confers the hereditary uniqueness of the cell. Only in some small viruses RNA also displays genetic functions. However, the hereditary autonomy of gene-initiated RNA of the cytoplasm is now very doubtful and it seems from recent work that genetic information is primarily nucleic.

What then is DNA? Chemical analysis reveals it to be a compound of high molecular weight (over 1,000,000) formed by the linkage of numerous smaller molecules. These molecules include a sugar, deoxyribose, phosphoric acid and four bases of which two are pyrimidines (thymine and cytosine) and two are purines (adenine and guanine). Through X-ray analysis of the molecular arrangement, Watson and Crick have shown that the polynucleotide chains of DNA normally assume the configuration of a double helix in which chains are hydrogen—bonded together through complementary base pairs. In the double helix, adenine and thymine form one base pair. Guanine and cytosine constitute the second pair. The DNA molecule may have thousands of turns in its spiral configuration and the possible variations, therefore, are astronomical in number and give an indefinite variety to the molecule. The Watson-Crick structure is attractive from a biological point of view because it provides a plausible basis for gene specificity, for gene replication and for gene mutation. Genetics is thus reaching its full powers in coalescence with biophysics and biochemistry. In principle, it should eventually

be possible to denote each phenotype as an exact sequence of amino acids in protein and the genetype as a corresponding sequence of nucleotides in DNA.

Molecular cross-breeding :

I shall cite a few examples to indicatet he extent of elegance that genetic experiments have now attained. All are familiar with cross-breeding experiments in plants and animals but few may have heard that hybrid molecules of DNA have been produced in the test tube. The experiment performed by Drs. P. Doty and J. Marmur of Harvard University, is based on the principle that when a heated sample of DNA is cooled very quickly, practically all of the strands remain separate. On the other hand, slow cooling results in the recombination of most of the strands into normal, biologically active DNA molecules. Doty and Marmur cultured one bacterial strain on a medium containing ordinary nitrogen of atomic weight 14 and another strain on a medium containing the heavier isotope, nitrogen-15. DNA extracted from both these strains was heated and quickly cooled. Then the preparations were combined and cooled slowly. The resulting mixture contained molecules of DNA whose weight showed that half of their nitrogen was N-14 and half N-15. In a biological test, the scientists crossed the DNA from a streptomycin resistant strain of bacteria with that from a strain sensitive to streptomycin. More than half of the new DNA was of the resistant type. This technique of cross-breeding at the molecular level would no doubt help in tracing the effects of various gene combinations and mutations. Artificial hybrids have also been produced between nucleic acids and proteins—I am referring to the reconstitution of the tobacco mosaic virus from the constituent RNA and protein. The experiments of Fraenkel-Conrat and his associates of the University of California have shown that the protein and nucleic acid components interact under appropriate conditions of pH concentration and time, to form particles which in physico-chemical respects resemble the original virus and which are likewise able to cause infection. These experiments performed with six strain mixtures also clearly demonstrated that RNA is the main genetic material of the tobacco mosaic virus; for the symptoms of infection evoked with the artificial hybrids always corresponded to the source of RNA, never to that of the protein. The homology of gene and virus in their fundamental aspects makes their overt differences even more puzzling. According to the prevalent view, DNA plays no active role in its own replication other than furnishing a useful pattern. Various nucleotide sequences should then be equally replicable. What then distinguishes virus nucleic acid, which replicates itself at the expense of the other pathways of cellular anabolism? Does the virus have a unique element of structure, either chemical or physical, so far undetected? Or does it instruct its own preferential synthesis by a code for supporting enzymes? These are questions to which only future experiments can provide answers.

The Watson-Crick model of DNA structure has received support from auto-radiographic studies involving the use of Tritium (H^3). Electron microscope pictures of chromosomes of many plants and animals suggest that before synthesis of DNA, the chromosome is made of 8 strands that are 200 to 250 angstroms in diameter. These 200-Å strands are in turn double and made of two 100-Å fibers. Thus, when one examines the fine structure of chromosomes, they seem to comprise several microfibrils. Bacteria and blue-green algae have, however, a different and less complex organization of both cytoplasm and nucleus. The nuclear vacaole, which contains the DNA, appears filled with uniformly distributed filaments about 25 Å thick. It also seems that in these cases the DNA is not combined with histones. Though differences thus exist in fine structure as well as chemical constitution, there is little doubt that DNA is the hereditary material both in bacteria and blue-green algae.

Molecular Biology and Origin of Life :

With the recognition of the self-replicating gene as the elementary basis of life, research can be directed towards the study of the origin of the first genetic molecule. Kornberg and Ochoa have reconstructed most of the events relating to DNA and RNA synthesis and replication, by means of extracts from bacteria and have almost reached the verge of proving duplication of genes in a chemically defined system in the test tube (they were awarded the Nobel Prize in Medicine and Physiology in 1959 for this research). However, the media in which such synthesis can occur in the cell or even in the test tube are extremely complex. Knowing that the simplest organisms would be the most dependent on their environments for raw materials, we have to find out the source of supply of precursors before living organisms had evolved the enzymes to manufacture them. Haldena, Oparin, Horowitz, Lederberg and others have shown the possible sources of probiotic nutrition. However, there is some controversy over whether nucleic acids were the first genes, partly because they are so complex and partly because their perfection hints at an interval of chemical evolution rather than one master stroke. The advantage of the nucleic acid hypothesis is that no other self-replicating polymers have so far been found. Although many steps in the generation of living molecules remain to be recreated, one cannot but marvel at the amount of information gathered on these problems during the past few years.

The fast developing science of exobiology or the study of life beyond the earth will in course of time provide a deeper insight into these problems. A timely warning has been given by Dr. Lederberg about the possible loss of scientific information if rigorous steps are not taken to exclude terrestrial contaminants from space vehicles. The overgrowth of terrestrial bacteria on Mars would destroy an inestimably valuable opportunity for understanding our own living nature. The indication by the concerned authorities both in the United States and the U.S.S.R. that this aspect will be kept in view on all space missions is an important step in the realisation of constructive exobiology.

Precision tools and Photosynthesis :

As in the field of genetics, advances in technique have helped us to understand better the most important single reaction on earth: the photo-reduction of carbondioxide. The quantum theory, which has over-shadowed probably all other development in physics in recent decades has also had an impact on biology. The first direct applications of quantum theory to photosynthesis by Warburg touched off a whole new development in this field and using these energy considerations, physicists like Franck, chemists like Calvin and plant physiologists like Emerson, French and Arnon have made several discoveries which have radically altered the old concepts concerning photosynthetic pathways. That we now have some reliable knowledge of the carbon compounds involved in photosynthesis is due in the main to two techniques evolved in recent years; these being the use of isotopes as tracers and paper partition chromatography. If the carbondioxide supplied to a photosynthesizing plant contains the radioisotope C^{14}, the sequence in which radioactivity appears in the compounds present in the plant will indicate the path taken by carbon in photosynthesis. However, the transformations undergone by intermediates in the metabolic processes of plants are extremely rapid, so that, if they are to be of any use, analyses must be made very soon after the beginning of photosynthesis with C^{14}. The development of the paper chromatographic technique has solved this problem.

The intermediates of photosynthesis have now been examined in a number of different plants, including unicellular green algae and higher plants such as barley

and geranium and the results have been similar in all cases. When the period of photosynthesis in the presence of C^{14} is as short as 5 seconds, the principal radioactive product is phosphoglyceric acid. If the period is larger, radioactivity appears especially in various phosphoric acid derivatives of sugars, in phosphopyruvic acid, in sucrose and in the aminoacid alanine. Radioactive phosphoglyceric acid is not formed in any appreciable amount during heterotrophic fixation of CO_2 (i. e., entry of CO_2 into biochemical reactions other than those of the photosynthetic process) and is thus specifically associated with photosynthesis. These experiments also confirm that the photochemical reaction is distinct from the fixation of CO_2 since chlorophyll is found to be quite free of radioactivity after a short period of photosynthesis with C^{14}.

The importance of gaining a deeper insight into the biochemical processes involved in photosynthesis will be obvious from the fact that through photosynthesis nearly 200 billion tons of carbon are fixed each year in complex and useful organic molecules. All the CO_2 in the atmosphere and all that is dissolved in the waters of the earth pass into this process and are completely renewed by respiration and the decay of organic matter once in every 300 years. All the oxygen in the atmosphere is renewed by photosynthesis once in about 2000 years.

It now seems possible that the original development of the use of light by organisms, through the agency of chlorophyll pigments, may have involved not primarily the synthesis of new organic matter, but rather the provision of stores of chemical energy for the cell. A few years ago, the process called photosynthetic phosphorylation was discovered and has since been intensively studied by Dr. D. I. Arnon of the University of California. By a mechanism as yet not fully understood, light forms the terminal high-energy phosphate bonds of adenosine triphosphate (ATP), which acts as a principal energy-carrier in the chemistry of the cell. One of the most interesting features of this process is that it is anaerobic and hence it could have been an efficient source of ATP at a time when our atmosphere still lacked oxygen. Among the many duties performed by ATP in cells, one of the most important is the supply of energy for organic syntheses. This direct utilisation of the energy of sunlight for usable chemical energy in the form of ATP would therefore already have had as by-product the synthesis of organic compounds.

While one marvels at the efficiency of the photosynthetic process, it is a curious fact that chlorophylls, the pigments universally used in photosynthesis, have absorption properties that seem just the opposite of what is wanted in a photosynthetic pigment. The energy of sunlight as it reaches the surface of the earth forms a broad maxium in the blue-green to green region of the spectrum, falling off at both shorter and longer wavelengths. Yet it is precisely in the blue-green and green, where the energy of sunlight is maximal, that the chlorophylls absorb light most poorly; this, indeed, in the reason for their green colour. In the violet and red bands where the absorption by chlorophyll is maximal the energy of sunlight is low. What then are the properties of chlorophylls that are so highly advantageous for photosynthesis as to override their disadvantageous absorption spectra? Recent studies have shown that chlorophyll possesses a high receptivity to light, an inertness of structure permitting it to store the energy and relay it to other molecules and a reactive site equipping it to transfer hydrogen in the critical reaction that ultimately binds hydrogen to carbon in the reduction of carbondioxide.

Photosynthetic organisms cope with deficiencies of chlorophyll in a variety of ways. As early as 1883, the German physiologist T. W. Engelmann pointed out that in the various types of algae other pigments must also function in photosynthesis. Among these are the carotenoid pigments in the green and brown algae and the

phycobilins, phycocyanin and phycoerythrin in the red and blue-green algae. Engelmann showed that each type of alga photosynthesizes best in light of the complementary colour; green algae in red light, brown algae in green light, red algae in blue light. As pointed out by him this is probably the basis for the layering of these types of algae at various depths in the ocean.

One may wonder how efficient this complicated mechanism, by which light energy is converted into chemical energy, is. It is clear from the available data that under natural or agricultural conditions higher plants are inefficient in this respect. If the potential chemical energy represented by the yield of an acre of a crop plant such as wheat is compared with the energy received in the form of light from the sun by the same area during the growing season, it is found that the net energy fixation is less than one percent of that received. In diatoms and other unicellular algae the average utilisation of solar energy is about three times higher than that of land plants. This efficiency can be further increased by providing the most favourable conditions for photosynthesis. For example, a yield of 30 per cent has been obtained in *Chlorella* cultures grown in a solution containing the requisite nutrient salts and CO_2 in optimum concentrations. However, in attempts to increase food supply through mass-culture of algae, it should be remembered that photosynthesis *per se* cannot help to increase the supply of proteins, which are the most difficult of organic nutrients for man to produce. Research should hence be directed towards the standardisation of techniques by which a great increase in both carbohydrate and protein production by plants can be brought about. Disregard of the need to maintain a nutritional balance will have adverse consequences on the health of the population.

The survey which I have made of these two most important problems of Biology is necessarily brief and inadequate. My object in selecting them is merely to draw your attention to what is most significant in Biology today. No doubt the most spectacular advance in science lately has been in Physics, *viz.*, splitting of atom, and tremendous release of energy which has consequently been obtained. In the next decade, it will be in the field of Biology that most important advances would occur. An insight into the mechanism of photosynthesis will provide a more satisfactory solution of the problem of food production for the growing millions of the world's population. It has been estimated that on an average about 50 million persons are being added annually. Apart from traditional method of crop growing, culturing of algae like *Chlorella* and artificial synthesis of food in factories utilising the energy of the sun may become practical possibilities. Apart from the efforts of plant-breeders, it is the manufacture of nitrogenous fertilizers which has provided a satisfactory method for increasing food production and it is this which has postponed starvation on a mass scale in over-populated countries. But the unravelling of the secret of chlorophyll holds the key for a more satisfactory solution of the food problem of the growing human beings. Similarly a more satisfactory understanding of the Biology of human reproduction will provide more practical methods of birth control, so that man if he wants to achieve a satisfactory standard of living, controls his rate of multiplication more wisely. With the application of new methods of food production and population control, it should be possible to provide amenities of food and shelter which are the basic human requirements to the masses, and lifting a large majority of them from the animal level of existence to the human level of existence. Thus the achievements of mankind in the field of art and culture also would be available to them. Their lives would be brightened and they would also share the feast of beauty which the human spirit has achieved in the field of art and literature.

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PRESIDENTIAL ADDRESS

TROPICAL STORMS

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I deeply appreciate the honour the Council of the Academy has done me by asking me to preside over the Physical Sciences Section at this session. Indeed I feel it to be a great privilege to be able to address you here at Allahabad where as a student, some 40 years back, I had the fortune of being a pupil of that illustrious man, Prof. Meghnad Saha who was also the founder of this Academy. I can therefore do nothing better than begin on this occasion by paying homage with you all to his memory.

To some of my audience, who are engaged in the pursuit of the pure sciences, perhaps an apology is due regarding my claim to address you from this chair. This privilege seems to be derived from the fact it was given to me to work in Meteorology for more than 30 years, a subject that is sometimes described as atmospheric physics although it is very often looked upon as a science still in its adolescence. It is perhaps appropriate for me to recall in the company of scientists – physicists, mathematicians, astronomers and chemists—the historical sequence of facts which goes to show that if meteorology has yet to attain maturity it is certainly an old experienced adolescent. If it is now a branch of applied physics, in a way it could be regarded as a foster-parent of modern physics. The Greek word 'meteorologia' was in use over 2000 years ago in a much wider sense than its corresponding equivalent is used today. The root word 'meteora' signified generally 'the things aloft', *i. e.,* things in the air and in the heavens. It embraced the natural phenomena of the material world. The growth of any science is marked by its division into subjects which, with advancing knowledge, themselves become branches of science. This is true of meteorology also. For, since Aristotle wrote the first text-book on meteorology some 2,300 years ago, this ancient subject has split up. Studies of certain classes of heavenly bodies have been set apart as astronomy; while that of natural phenomena of the air, including atmospheric optics and the aurora, developed into the modern subject of physics. The study of meteors, as commonly understood, has been taken up by specialists, and the natural philosophy of the atmosphere, the study of weather, remains as the survivor from the original domain of meteorology of Aristotle.

Thus, meteorology, as the word was originally used, is one of the oldest of the sciences, astronomy and physics being its foster-children. This is not merely a historical fancy. For, it was primarily the study of the atmosphere that led to the deduction of the general physical laws of the gases in the hands of Boyle, Hook,

Marriott and others. The most renowned experimental work of Pascal was one of his earliest scientific experiments, the Puy-de-Dome experiment, demonstrating that air had weight and that its pressure was greater at the foot of a hill than at the top. Again, Dalton deduced his law of partial pressures from his contemplations on the mixture of the atmospheric gases. And even his ideas concerning atomic structure originated from his investigations into the physical properties of the gases of the atmosphere, and not from studies of the chemical properties of substances as one would normally have believed.

The evolution of science from the early times, as explained, is only natural. Man has always felt interested in, he even wondered at, atmospheric phenomena as he has been in the case of the motion of the heavenly bodies. And this interest has always drawn him out to making attempts at explaining the phenomena. But the atmosphere represents a very vast system of great complexity and not amenable to control by human agency. It has many phases and many degrees of freedom. Hence meteorologists, at all times, have tried to understand the atmospheric phenomena by parts. By removing a small portion of the atmosphere into the laboratory, they replicated for study a much smaller and simpler system with few degrees of freedom under controlled conditions. In this process, the meteorologist became a physicist whose experimental method of work follows the study of a controlled isolated system. The physicist applies the laws gathered from such simple systemsts to an idealised atmosphere with certain postulates. On the other hand, the meterologist aims at understanding and describing, in a general but detailed way, the circulation of the real and complex atmospheric system. However, for the handling of his problems the meteorologist's mental equipment has to include knowledge of the laws of thermodynamics, aerodynamics, radiation and statics, among many others. But even so, here I quote from the writing of an eminent meteorologist,—"the best description by the best equipped meteorologist of the atmospheric complex is still incomplete, and perhaps not yet ready for the genius of a Kepler who will represent the atmosphereic structure and circulation so completely and perfectly that a Newton may arise to evolve its laws".

Having thus attempted to justify my stand here, and somewhat on a personal note, I would like to recall the day, more than 32 years ago, on which I happened to join the band of meteorologists working in a small office on the heights of Simla. It was the 31st of October 1927 when a very severe cyclone from the Bay of Bengal was about to cross the coast of the Indian Peninsula near Nellore in Andhra-desh. This devastating storm was in many ways a very typical and striking example of tropical revolving storms; and watching its course and behaviour, as depicted on the synoptic weather charts, gave me my very first initiation into the subject of meteorology. Following the trend of the thoughts, I have chosen to speak to you today of the Energy of Tropical Storms.

Tropical storms are met with in most of the ocean areas in the tropics. These appalling developments are known by different local names in different regions, being called hurricanes in the West-Indies (Caribbean Sea) and South Indian Ocean near Mauritius, typhoons in the western North Pacific, Cyclones in the Bay of Bengal and Arabian Sea and Willy-willies in Western Australia.

The general character of the above named manifestations are all about the same. These can all be described, therefore, as large whirls or vortices in the atmosphere with diameters from 300 to 1000 kilometres and having nearly, though not exactly, vertical axes. The air rotates in circles with converging drifts inwards

towards the axis at all levels. The speed of the air motion can reach 100 m. p. h. or more or less. This leads to a representation on the weather map as a picture with a system of closely packed nearly circular isobars. The effect of the steep pressure gradient is balanced by the rotation of the earth and the velocity of the spin of the air. At the centre of the vortex is a calm area of a few miles in diameter, called the "Eye" of the storm. Round this calm centre lies the ring of the strongest winds; and as we go farther away from the centre the wind velocity decreases inversely as the distance from the centre. The translatory motion of the entire system is slow, about 10 miles per hour or thereabout.

As the storm passes over a station the weather that is experienced is quite characteristic. Torrential rain falls, very often with lightning and thunderstorm; the wind increases in violence until the eye of the storm passes over, when it falls to a calm or almost so; then the wind suddenly resumes its full fury, but from the opposite direction, reaching hurricane force. The sea in the central area raises enormous waves and is very confused and hence very destructive. The waves generated by the storm-wind go along the direction of travel of the storm and raise an ocean-swell that travels faster than the storm itself. All these features are consistent with the conception of air converging spirally from all sides towards the centre of the cyclone. If the convergence towards the centre is to be maintained, an arrangement has to be provided by which the ascending air within the core can be disposed of after depositing its moisture as rain.

The problems connected with the formation, development and maintenance of the tropical cyclones are indeed very complex, and many theories have been put forward by scientists from time to time to explain the main features of these phenomena. The earliest was the convection theory, advanced many years ago, which held the ground generally until the early 1930's. But it was realised later that convection alone is not enough to explain the starting mechanism of these storms, nor what brings about the initial fall of air-pressure at its centre, nor also as to why cyclones are not more numerous than they actually are found to be. After the 1930's followed a period in which meteorologists tried to apply the concepts of air-mass methods, developed by the Norwegian school of meteorologists, to tropical weather analysis. The application of these ideas did provide a source of energy for starting the storm. But still the fact that some tropical storms formed in the region of the trade-winds, where the air is homogeneous without appreciable temperature or humidity discontinuity, remained a difficulty. There are a few other objections also to the acceptance of the frontal theory of the formation of tropical cyclones.

In recent years a more comprehensive and realistic, and perhaps the most acceptable, hypothesis has been developed from the contributions of many scientists—notably Herbert Riehl of the Department of Meteorology, Chicago University. Riehl and others have compared tropical cyclones to man-made engines, and have formulated five stages in their development. These are—

(a) The main source of energy of these storms is in the latent heat of condensation of water-vapour into rain within the storm field.

(b) A few, and specific, suitable arrangements of the winds can act as the starting mechanism, and the kinetic energy of these wind systems furnishes the initial independent supply of energy.

(c) Condensation during the ascent of air within the storm is the means by which latent heat is transformed into sensible heat. The starting mechanism itself must therefore be able to initiate such ascent. Outflow of the

air at higher levels and a corresponding inflow at the lower levels develop to compensate the upper outflow of air, *i. e.*, kinetic energy of radial motion is generated. The wind circulation in the vertical must overcome and survive the influences that tend to destroy the circulation.

(d) Coriolis force and centrifugal force convert radial to tangential kinetic energy, and after some time the tangential energy predominates.

(e) Winds at the higher tropospheric level provide the cooling system which transports the excess heat to regions outside the storm area.

From the above formulation we may state the mechanism of the tropical cyclones, from considerations of their sources of energy, to be somewhat as follows. The most important source of energy of tropical storms is the release of the latent heat of condensation of water-vapour into rain. The addition of moisture to the atmosphere requires heat, which is supplied directly or indirectly by the sun. As the warm moist air overlying the tropical seas flows into the circulation area of the tropical storm at its lower levels, the air starts rising. Since the ascending air can expand against the lower pressure aloft, it also cools thereby and soon becomes saturated air, so that thereafter some of the moisture is forced to condense out. Now, although the amount of air that so rises is large, yet the amount of energy realisable from ascending air is limited by several factors. These are, the pressure, temperature and relative humidity of the air at the time when it started rising and the vertical gradient of temperature of the air surrounding the cyclone, or the 'environment' of the ascending air. The temperature and humidity of the surface air are markedly influenced by the temperature of the ocean-surface over which it flows, which thus limits the amount of energy available for both the formation and maintenance of the cyclone.

We may therefore liken the tropical cyclone very much to a heat-engine, which means that there should be a heat source and a cold sink. It is a well-known observed fact that the inside core of a tropical storm is warmer than its surroundings, and it is this warm core which can be regarded as the heat source. The air flowing into the cyclone at its lower levels ascends from near the surface to the upper regions and is removed from the cyclone area at the upper atmospheric region. It then gets mixed up with the surrounding air and gradually sinks down further afield. This process results in the release of kinetic energy of the wind and can take place only when the temperature increases towards the cyclone centre.

We are now in a position to consider the energy budget of tropical cyclones. Brunt estimated the kinetic energy of the normal westward flow of air of the equitorial belt of atmospheric circulation to be 1.35×10^{27} ergs, *i. e.*, 4×10^{13} kilowatt-hours. This refers to approximately one half of the atmosphere. Allowing for all the factors, he obtained a rough measure of the kinetic energy of the normal circulation of the whole atmosphere as 3×10^{27} ergs or 10^{14} kilowatt-hours. This, let me repeat, is the kinetic energy of the normal atmospheric circulation. A computation by Napier Shaw gives the energy of a cyclone of the temperate latitudes, 10 millibars deep and of diameter 1400 kilometeres, to be 1.5×10^{24} ergs. According to Brunt's calculation quoted just before, the average energy of the normal circulation corresponding to the area of the cyclone, namely of diameter 1400 kilometres, would be 10^{24} ergs. This would give a 50% increase of energy over any region as a result of the disturbance of the area by a cyclone.

The above computations gave the value in respect of cyclones of the temperate regions. It would be interesting to compare this with that corresponding to

tropical cyclones which, as a rule, manifest much greater release of energy. A computation of energy was made by the present author during an investigation on cyclones in the Indian seas. A very typical case was the cyclones in the Bay of Bengal in November 1926 having a diameter of 360 kilometres (200 miles). The phase of development selected for the energy computation was for November 24th, and the necessary measurements were made from the 8 a. m. weather chart of that day. The velocity of the air motion, averaged over the area within the inner zone, came to 32 m/s (about 70 m. p. h.). Taking the mean velocity over the entire cyclonic field to be half this value (which is a very fair approximation) the kinetic energy of the wind worked out to be 8×10^{24} ergs nearly. By transforming this value to correspond to an area comparable with that of the temperate cyclone investigated by Napier Shaw, the energy value for the Bay of Bengal cyclone came out as 4×10^{25} ergs, which is nearly 25 times the energy of the cyclone of the temperate latitude. This is a very striking result which, nevertheless, is fairly representative of the facts as known and observed. The values given here are only rough figures, indicating the order of the magnitudes. The higher value of the kinetic energy of the tropical cyclone is no doubt explainable by the higher moisture content of the air masses that come into play in the structure of the tropical storms as compared to the moisture values in the higher latitudes.

It has been stated before that the essential feature of a cyclone is the deficiency of air pressure at its centre. This can be looked upon as a result of the removal of a corresponding amount of air from the cyclonic field. It is possible to make reasonable estimates of the extent to which air must be removed from the cyclonic vortex, and disposed of at the top, in order to produce the barometric low of a certain depth. Calculations have been made for such estimates in respect of tropical storms, depressions of temperate latitudes and tornadoes. Napier Shaw was able to show that in nature the removal of air from storm areas is effected in a truly gigantic scale. For example, in the case of a large Atlantic depression in the temperate latitudes, of 3800 kilometres diameter, the amount of air removed would weigh nearly two million million tons, while in the case of a tropical storm of diameter 1150 kilometres (i. e., less than a third the diameter) the weight of air removed would come out to be nearly 17 thousand million tons.

Another energy calculation will show in a very interesting way the vastness of the scale of things concerning tropical storms. That is an estimate of the energy liberated per day within the cyclone in the form of heat energy. Many computations go to show that this heat energy liberated varies from 2 to 6×10^{26} ergs. The higher figure, which is perhaps exceeded in the case of fully mature cyclones, is equal to nearly 16 trillion trillion kilowatt-hours per day. Just compare this with the total electrical power generated in a big and industrially advanced country like the United States, which is of the order of 2 billion kilowatt-hours per day, i. e., only a fraction of the energy of the cyclone. It must be remembered, however, that with all this the cyclone is not after all a very efficient engine for, converting heat energy into mechanical energy, its efficiency being only about 3 per cent! Nevertheless, if the total heat liberated by a cyclone could be converted into electricity, a cyclone could provide in one day more than 6 months' supply of power for the entire United States!

In the wake of these thoughts the mind naturally is curious to know if it will ever be possible to harness the energy of the cyclones and store the same for man's use. This may sound fanciful; but no one can doubt the potentiality of the cyclone at least as a source of fresh water supply. Man has already been thinking of supplies of fresh water for areas short of water by making sea-water salt free, but

no economical method has yet been devised. The cyclone does this very thing. Billions of tons of water are evaporated from the oceans each day into air which is drawn into the circulation of cyclones. This water ascends to higher regions as vast cloud systems and falls out again after condensation as rain-water. If only this could be collected and adequately stored, as is done in some measure in certain hydro-electric projects in some areas, the 'Unchained Goddess' would truly be serving man at his will.

Next, one may ask the question, is there any possibility of controlling the cyclones? This question has certainly been raised with sources of atomic power within the grasp of man in the recent years. Here I should like to give you some energy comparisons, which we owe to some scientists' calculations, between the energy of storms and the energy associated with atomic and nuclear explosions. It is computed that an ordinary summer afternoon thunderstorm releases as much energy as about 13 atomic bombs of the type that were released over Nagasaki. It is also seen that an average cyclone can discharge some 20 thousand million tons of water in 24 hours, which is equivalent to the energy of 500,000 atomic bombs. An atomic explosion in Test Baker lifted some 10 million tons of water, while one cyclone is capable of pouring in about 2,500 million tons of water on the island of Puerto Rico within a few hours only, and this was only a fraction of the total rainfall over the whole area of the storm. Another calculation shows that a cyclone of 800 kilometres diameter released latent heat of condensation at the rate of 10 trillion horse-power, maintaining this rate for as long as 10 days! With the orders of values such as those given here, there seems to be little chance for man, with the power resources available to him, being able to effectively interfere with the forces of nature in their gigantic scale and attempt to control cyclones or to divert them from their paths.

In recent times suggestions have been made for controlling the movement of cyclones by another method, namely by seeding cyclones with dry ice or silver iodide, or other suitable nucleating agents by the help of aircraft. These suggestions follow from the theoretical possibility of diverting a cyclone from its path by seeding the cloud formations in a certain portion of the cyclone in the hope of concentrating the energy of condensation in that quadrant through an increase of rainfal due to the cloud seeding. According to some scientists this concentration of rainfall in one quadrant has the effect of leading the storm centre towards that region. Already attempts have been made to effect this, for example, in the case of a cyclone passing over Cuba in October 1947. In this attempt the cyclone under experiment was seeded twice. However, the recent examination of the data collected from this experiment show that the apparent alteration of the course of the storm had already taken place about seven hours before the seeding was done. Again, in 1958 the National Hurricane Research Project of America made four hurricane seeding experiments. Till now the full analysis of the relevant data and associated observations has not been completed, but there do not seem to have been any obvious consequences of the seeding on the hurricanes.

The position, therefore, seems to be that the almost unbelieveably large quantities of energy associated with cyclones prelude human interference with their course or behaviour. However, if we could obtain more precise and complete knowledge of the structure, mechanics of formation, energy-budget, dissipation and movement of cyclones, it may come out to be that the energy of the cyclone itself could be used to start in some way some chain reaction which could cause the storm to destroy itself. In other words, the only method of controlling a cyclone may lie within the cyclone itself; for no other source of energy would be adequate enough to make any impression on a well-developed tropical cyclone,

The possibility of controlling cyclones, as visualised just now, brings us to another interesting point. Even granting that it did become possible to effect some control over these natural manifestations, it is very doubtful, indeed, if to do so would be at all wise. This is because the cyclone perhaps plays an essential and a rather vital role in the general circulation of the atmosphere. It may be one of the very effective and important ways in which the heat balance of the earth, between the tropics and the polar regions, is maintained. We know that the tropics and the sub-tropics receive more heat from the sun than they lose by radiation, while the other regions of the globe lose more than they receive. Now, the excess of heat received in the tropics must be transported polewards to prevent a gradual cooling of the poles further and a gradual warming up of the equatorial regions. Cyclones provide one means, besides others, of this transport of heat polewards, and thereby maintaining the heat-balance. It is very likely that cyclones occur when the other methods available to nature of maintaining the heat-balance prove inadequate for some reason and heat begins to accumulate in the tropics beyond legitimate limits. So if cyclone control did become successful and none of them were allowed to go through their full life-cycle, nature would undoubtedly have to find some other means of maintaining the balance. And who can tell that this new alternative might not prove to be greater disaster to human beings than the cyclone which was sought to be controlled?

One fact, however, remains, and that is the challenge which cyclones throw to the meteorologists, who have yet to learn a great deal more about the nature of these entities. To meet this challenge the meterological services of the developed countries are pressing forward with research programmes on very large scales, one example of which has already been mentioned earlier. This is the National Hurricane Research Project, set up by the United States Weather Bureau in 1956, in which the nation's best scientific talent has been enlisted to find out as much as possible about hurricane formation and development with the aid of specially instrumented aircraft and other most modern equipment. Among other things, the project is also to develop experimental models of cyclones for use with high-speed electronic computers in forecasting cyclone movements; to use coastal radars for analysing cyclone-structure and their micro-movements; and to investigate the distribution of energy in the cyclone for preparing an accurate energy-budget of the cyclones.

To aid the cyclone investigation projects in the obtaining of vital information concerning cyclones, all possible methods are being pressed into commission, and every modern technological development utilised in the associated instrumentation. Wireless reports from ships on the high seas and aircraft reconnaissance are already well-known methods employed, and radars are being more and more brought into use for these researches. But an even more spectular means promises to be available in the earth-satellites. Equipped with sensitive photo-electric cells which can detect differences in the intensities of light reflected from different objects like earth, water, clouds, etc., these satellites would be made to photograph the cloud-structures within a cyclonic field in great detail. During daylight hours, while the photographs are being made, over the cyclone in each orbital passage of the satellite, the photographic impulses are stored on a magnetic tape. When the satellite comes to the dark side of the earth, these impulses are transmitted by radio to the satellite tracking station and from there to the cyclone research centre. The research centre is equipped with a high-speed electronic computer capable of solving the several hundred thousand sets of simultaneous equations for obtaining the exact position of the satellite at the times the individual photographs were taken. This technique of obtaining meteorological data for cyclones by means of earth-satellites has already been tried out-particularly in the United States in

Tiros I and Tiros II. It is even contemplated that a satellite might be launched so as to move in its orbit with an angular velocity equal to that of the earth, in order that it may be possible to locate it over a cyclone-centre and obtain successive photographs of the cloud formations in the cyclonic field. These are very stimulating thoughts and visions indeed for scientists and technologists alike.

Whether or not India would be one of the countries to take up experiments with earth-satellites, I should like to conclude this address by making a meteorologist's plea from this platform. That is a plea for the establishment of a tropical meteorological research centre with a definite project for investigations on tropical cyclones in this country. The centre should be equipped with the latest devices which modern technique has evolved for work on this line and should be capable of collaboration with other institutions as and when required to get the best results; and such collaboration should be permissible to the fullest extent and most freely, because such projects are essentially run on the basis of team-work of the closest kind. India is fortunate in this respect, because the country offers unique opportunities for the establishment of such an organisation, and contribute materially to the growing science of cyclonology with considerable benefit to the country's cyclone forecasting service. Because the Indian area and its neighbourhood is visited by the most devastating and fully developed cyclones of the tropical seas, there is a fine meteorological organisation with competent scientific staff and with excellent traditions of research work, and also there are other interested institutions in the country capable of rendering very valuable co-operation with their capable scientific staff and other resources for helping in cyclone-research. The development of such a research centre should yield a very rich harvest in the field of tropical meteorology, and cyclonology in particular.

I thank you once more for giving me this opportunity of being with you and for the patient hearing you have given me.

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PRESIDENTIAL ADDRESS

"THE STRUCTURE OF THE CHROMOSOME"

By

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During the last few years plenty of evidence has accumulated that it is the DNA that carries genetic information, and although a good part of the chromosome, which is accepted to be the carrier of the hereditary material, is composed of proteins, the genetic information is transmitted exclusively through the DNA molecules. The old concept of genes being arranged on the chromosome like beads on a string has had to be abandoned, for it has been shown that crossing-over takes place not only between genes but also between parts of genes (41, 42). Although the gene is undoubtedly a unit of function, it is not a structural unit, and may contain several separate sites of mutation (13,42). Briefly, as Pontecorvo (58) puts it, genes A B C D consist each of several building blocks on the chromosomes, a b a c d e a b d e f a b a c d e f e, so that gene A corresponds to a b a c d e a, gene B to b d e f a b a c, and C to b a c d e f e. Although the genes are functionally discrete and separable, the concept of structural discreteness is no longer justified. The structure of the entire chromosome and the pattern of the arrangement of the structural elements in it, are of fundamental importance in determining the organisation of the living system. This has become increasingly evident ever since the discovery of the position effect by Sturtevant. The mutation bar, e.g., which drastically reduces the number of eye facets in *Drosophila melanogaster*, involves a repetition of certain of the structural elements in a section of the X-chromosome, which has for its consequence the separation of elements which are neighbours in the normal chromosome and approximation of elements which are normally placed far apart. Thus, the importance of pattern at the macromolecular level in the chromosome is obvious. It is equally obvious, however, at the molecular level. DNA becomes associated with proteins to give rise to chromosomes in all organisms higher than bacteria and blue-green algae, in which information is carried by pure DNA. In bacteria all the genes naturally form a single linkage group and there occurs no recombination and no translocation. These become possible only after DNA and proteins, mostly histone, become integrated to originate chromosomes. Sections of DNA threads control different steps in chains of reactions and there is a correspondance between steps in such chains of reactions and the spatial order of the controlling segments of DNA threads, e.g. in *Salmonella typhimurium* in case of tryptophane mutants. The question immediately arises as to what constitutes the linear differentiation of the DNA thread in the bacteria (and also the longitudinal differentiation of chromosomes in the higher organisms). A DNA molecule, on the basis of Watson and Crick model (59), consists of two inter-connected, coiled strands, composed each of sequences of four bases (adenine, guanine, thymine and cytosine— two purines and two pyrimidines) with each base linked with a molecule of the sugar deoxyribose and every two adjacent molecules of the sugar linked through phosphoric acid. The sequence of the bases must differ in different structural elements of the chromosomes to give rise to the differences between the discrete elements

a b c d............that constitute a gene. The DNA molecules vary structurally along the length of the chromosome. Ignoring for the moment the linkage of DNA with proteins, how are the DNA molecules packed inside the chromosome ? The idea has been widely entertained that a chromosome is a bundle of DNA threads (each thread consisting of a series of DNA molecules). This concept has been expressed by the term polyteny and derives much support from the structure of the giant salivary-gland chromosomes of certain Diptera, which are demonstrably composed of identical threads paired longitudinally from end to end. Nevertheless, it may be mentioned that the idea has been broached that a chromosome consists of a single chain of DNA molecules with no lateral redundancy (58). The reasoning behind this suggestion is that 'crossing-over occurs between chromatids and not between sub-units' and that the chromatid 'contains the unit amount of DNA for each organism'. It is, however, well known that breakage in sub-chromatids and recombination between sub-chromatids can occur both spontaneously (Darlington and Kefallinou in *Gasteria* (18) and Srivastava in *Poecilocerus* (51)) and in radiation experiments (La Cour and Rutishauser (30), Marquardt (33), Östergren and Wakonig (37)). It is difficult to see how the recombination between sub-chromatids could be a recombination between a single strand of one DNA molecule and one strand of another, that 'a half-chromatid break could perhaps be a break in only one of the two strands in a DNA molecule.' As Waddington (58) pointed out, it is not quite feasible to postulate breakage and recombination in a chain of DNA molecules and Gall (58) is certainly on debatable ground in thinking that the problem of recombination between such molecular chains is on a par with that between macromolecular strands consisting of bundles of DNA threads, for the latter is obviously far easier of accomplishment. If, however, Gall's view is correct and the mitotic chromosome does consist of a linear order of DNA molecules linked together, it becomes necessary to assume that even the leptotene thread, which appears to be fully spun out, is either spirally twisted or it has the DNA molecular chain folded upon itself in several turns, since the chromosome thread is detectable by ordinary microscopy and a DNA molecular chain, as it has a thickness of about 20 Å only, will be invisible even in the electron microscope. The second alternative is obviously out of the question, for recombination between such complexly folded threads is clearly fraught with too much of complications. It is more feasible to postulate that whenever the chromosome becomes visible to light microscopy, it is in a state of high molecular spiralization. Although there is nothing really fantastic or absurd about this idea, it is not likely to commend itself strongly to competent critical opinion. Wherever the chromonemal thread is well spun out, as is the case with the leptotene threads, the lampbrush chromosomes, and the giant-chromosomes of the larval salivary gland cells of certain Diptera, it is observed not to be of uniform thickness, but to be beset with granules at intervals. These granules are called chromomeres (or bands) and are specially clearly observed in lampbrush chromosomes. How to explain the presence of the chromomeres on the basis of this assumption ? Callan (15, 16, 57, 58) has adduced evidence of the continuity of the chromomere with the chromonema in the lampbrush chromosomes of *Triturus*. When the lateral loops are small, the chromomeres are voluminous, but the latter diminish in volume as the loops increase in length, till in the fully developed lampbrush chromosomes with maximum sizes of the lateral loops, the chromomeres almost totally disappear from view, as if these (chromomeres) were balls of highly coiled threads which become drawn out into the lateral loops. Probably it is a safe assumption that the chromomeres of the ordinary meiotic prophase correspond to the chromomeres of the lampbrush chromosomes, (19-22, 24-27) which are diplotene chromosomes, although somewhat specialized. It is not necessary to consider the controversy between the exponents of the granular and chromonemal concepts of the chromomeres (Strasburgher, Rückert, Balbiani, Swanson, Kuwada,

Ris, White, Darlington, etc. (48)). Confining our attention for the moment to the lampbrush chromosomes of newts, Callan's finding is consonant with the view that the lateral loop is a part of the chromosome which becomes untwisted or drawn out, that is the chromomeres are not granules, but tightly coiled sections of the chromonema. This idea is further supported by the discovery by Gall (26) of the presence of a chromonemal core as the axis of the loop round which cluster RNA-protein granules. This finding does seem to indicate that the loop is a prolongation of the chromonema through the chromomeres and that the chromomere itself is a highly coiled section of the chromonema. This is the bais of Gall's scheme of the structure of the lampbrush chromosome. In this scheme the chromonema is taken to be double consisting of two threads, each of which bears its own series of chromomeres, the apparently single chromomere being each actually double. Callan (58) points out that the interchromomeric fibrillae of the lampbrush chromosomes are single, although naturally he is not very emphatic about it. "I personally see only one strand", he points out, but goes on immediately to say that 'the chromosome is in effect a series of single-double structures.' In short, the chromomeres, which must be considered to be highly condensed sections of the chromonema, since they come out into the loop-threads, on Callan's showing, are double, but both chromomeres of any locus are continuous with a single chromonemal thread behind and in front. Theoretically this interpretation is exceedingly difficult to accept. The incidence of double bridges (Callan (15,16), Gall (26), Wischnitzer (61), Srivastava and Bhatnagar (52)) supports the basic idea of Gall that the loop arises as a diverticulum of the chromomeric thread from its middle, for it is in this zone of the discontinuity of the chromomeric material that the chromomere (actually two chromomeres, closely approximated to appear as one) splits into two, the two loop-threads of the two affected chromomeres becoming stretched to produce the double bridge. It is necessary, however, to take into account the fact that Wischnitzer (61) has reported single loop-bridges in *Triturus,* which means that the chromomere affected bore a single loop. It is not improbable, however, that the single loop-bridge formation is due to the accidental destruction of one of the two loops during manipulation. Srivastava and Bhatnagar (52) actually report injury to one of the two loops in a double loop-bridge, although both the strands remained in the loop-bridge. Wischnitzer himself (61) discounts this idea, but it is not unlikely to happen. More unfavourable to Gall's interpretation is the finding of Wischnitzer (61) that not only the loops but even a good many of the chromomeres can be removed without disrupting the continuity of the chromonema. That the loops can be removed without affecting the continuity of the central chromonema was shown by Gall (25) and has also been reported by Srivastava and Bhatnagar. On Gall's hypothesis mere removal of loops should cause the disruption of the chromonema, as it would bring about the split of each of the affected chromomere into two, unless there is something to cause the split halves of a chromomere to stick together. And the removal of chromomeres (61) should necessarily cause the break-up of the chromonema. It is obvious that this attractive hypothesis of Gall is not firmly established. This hypothesis, however, accepts the major clause of Ris's (43) interpretation of chromosome morphology. Ris' contention is that chromomeres, lateral loops and matrix do not exist as special structural elements of chromosomes. Chromomeres are produced by the overlapping of chromonemal helices and higher degree of spiralization of the chromonema at certain positions ; the lateral loops (in ordinary diplotene-diakinetic bivalents and also in the lampbrush chromosomes) are simply the lateral projections of the chromonema ; and the appearance of the matrix on the sides of the diplotene-diakinetic chromosomes is due to a partial lateral projection of a chromonema on each side, while all the chromonemata remain in the centre, creating the appearance of a denser chromosomal core and a lighter matrix round it. Wischnitzer's (61)

[35]

diagrammatic representation of Ris's interpretation of the chromomere and the lateral loop (4 c) is somewhat inadequate, as he ignores the spiralization part. It is true that Gall's (26) recent interpretation of chromomere and loop structure is different from Ris's original (43) view, it nevertheless contains his basic idea that the chromomeres and the loops are spiralized and laterally projecting segments of the chromonemata respectively. Another finding of Gall (26) which does not offer any support to his hypothesis is that even electron microscope photographs of chromomeres show these to be homogeneous-looking, ball-like structures, revealing no indication of the existence of thread-work (Fig. 11—magnification $\times 15,700$), although the loop-axis core, which is a continuation of the chromonema, is revealed.

More recently, Ris (44, 45, 46, 28) has adduced further evidence in support of his interpretation of the lateral loop structure. Ris finds that all parts of meiotic prophase chromosomes of a number of animals and plants (including lampbrush chromosomes) consist of bundles of microfibrils, which are remarkably uniform in thickness, namely, about 500-600 Å. Bundles of microfibrils constitute the central chromonema, chromomeres and the lateral loops. Thus, morphologically, there is no distinction between the chromonema and the lateral loop, although Ris (28, page 126) seems to accept the commonly mentioned finding that the loops of lampbrush chromosomes are devoid of DNA. He writes, speaking of the loops on the pachytene chromosomes of the grasshopper, *Chortophaga viridifasciata*, that these loops are thinner than those of the lampbrush chromosomes and that they also differ from them in being Feulgen-positive, clearly implying that the lateral loops of the lampbrush chromosomes are Feulgen-negative. In this very paper (28) Ris refers to and affirms his earlier work (45) which showed that the volume of oocytes and of their nucleic acid content closely parallels the thickness of the lampbrush chromosome loops. Ris does not probably mean by this that the loops themselves contain DNA. He categorically states (28) that the loops are Feulgen-negative. He has further introduced another idea into his interpretation of the structure of the lampbrush chromosomes (58). He argues that during its development the lampbrush chromosome registers an increase in mass and volume which is 'many hundred fold' and as neither DNA nor histone increases during this process, the added material must be non-histone protein and RNA, and this takes the form of loops. He thinks that the loop material must have been added between DNA-containing sections. Ris's hypothesis would mean that the chromosome consists of genetic and non-genetic material placed alternately. So far as the constancy of DNA under normal condition is concerned, it seems to be well established (Lison and Pasteels 31, 32; Alfert and Swift 2; Boivin etc. 12; Swift 53, 54; Swift and Kleinfeldt 55; McMaster 34; Srivastava 49). Ris is, however, on dubious ground in postulating absence of DNA from the loops. The fact that the loops do not react positively to the Feulgen dye does not necessarily indicate absence of DNA. It is not only the loops that are Feulgen-negative; the main chromonemal axis is also Feulgen-negative. It is obvious that unless the concentration of DNA is above a certain threshold quantity, it will not give an indication of positive reaction visible under the microscope. However, even if Ris's suggestion turns out to be incorrect, it seems there is no escape from the fact that, as Waddington (58 page 50) points out, cytological appearances suggest a distinction between two kinds of genetical material, the material that comes out into the loop and possibly organizes the synthesis of ribonucleoproteins around it, and the material that does not so come out and remains as inter-chromomeric fibrillae. Genetic experience, on the other hand, seems to indicate that it is not necessary to postulate the existence of an inter-genic substance for chromosome breakage, since zones of fission exist within the genes themselves.

Persistence of the central strand of the lampbrush chromosome after the

removal of the loops Ris (58) explains on the ground of the stickiness of the chromomeres, which are, according to him, the heterochromatic segments of the chromonema. Heterochromatic and euchromatic sections of chromosomes differ in being out of step in spiralization and despiralization cycle. When the euchromatic parts are maximally stretched out, as during the leptotene period, the heterochromatic parts experience the maximum degree of spiral condensation, and the reverse relationship holds good too, as shown by the fact that the sex chromosomes are less condensed at the metaphase than at the prophase. This behavioural difference must necessarily reflect a constitutional difference (Srivastava 48). But that apart, if heterochromatin exhibits this precocious condensation, it is only logical to consider the condensed sections of the chromosomes to be composed of heterochromatin. Oehlkers and Eberle (36) have shown this for the plant *Billevalia.* They find that the leptotene chromonema is fully uniformly stretched, showing no condensed sections at all—it is devoid of chromomeres. But it does not stain uniformly, densely and lightly stained sections alternating. Oehlkers's photographs clearly show lightly and densely stained sections of leptotene chromonema. Spiralization of the densely stainable parts of the thread occurs much more rapidly and starts earlier than that of the lightly stainable parts, with the result that the densely stainable chromonemal sections become changed into granular formations by the time the late leptotene stage is reached. If this interpretation is one of general validity, the chromomeres of the lampbrush chromosomes also must be the heterochromatic segments of the chromonema, as Ris (28, 58) holds. (Srivastava (50) does not find the leptotene threads of *Dissosteira* to be composed of differentially stained sections.) This interpretation is confronted with two difficulties, one of which has already been mentioned, namely, that the central chromonema persists after the loops are removed and even after the chromomeres are removed. Ris's explanation that the persistence of de-looped chromonema is due to the stickiness of the chromomeres may or may not be valid, but it certainly is not an adequate explanation for the chromonemal persistence after the removal of the chromomeres themselves, if, of course, Wischnitzer's (61) observation is correct, which it appears to be. The second difficulty is that in the lampbrush chromosomes of Amphibia, chromomeres form by far the greater part of the chromonema. For example, in Gall's (26) excellent photographs (pages 6 & 10), the inter-chromomeric fibrillae account only for less than one fourth of the total length of the chromonema photographed, while the chromomeric length amounts to more than three-fourths. The same relationship is to be observed in all the other clear photographs (Wischnitzer, 61, figs. 11,13; Callan, 28, pages 4, 5, 6; Srivastava and Bhatnagar, 52). It is difficult to reconcile this quantitative relationship with the situation in the leptotene threads of organisms in general including Amphibia, where the relationship of euchromatin and heterochromatin (chromomeres) is the reverse of what obtains in the lampbrush chromosomes (see 17, 60). Also, heterochromatin is thought to be mostly devoid of oligogenes; this, as applied to the lampbrush chromosomes, would mean that more than three-fourths of a chromosome is genetically inert or contains only polygenes. There is strong reason to hold that the lampbrush chromomeres and the bands of the dipteran salivary gland chromosomes are the active zones (3-11, 23, 35). This is obvious from the fact that the loop threads organise the formation of ribonucleoprotein granules in lampbrush chromosomes, and that in puff formations in the different regions of the salivary gland chromosomes in different organs of dipteran larvae, involving single bands, there is increased formation of DNA and RNA (14, 38, 39, 58). So these regions are not inert and it is doubtful if they can be considered heterochromatic as Ris holds.

The comparison between the fibrils of the Balbiani ring and the loops of lampbrush chromosomes drawn by several writers (Alfert, I; Gall, 26; Beermann,

11; Pavan, 58) is certainly justified, although the salivary gland chromosomes are polytene and the lampbrush chromosomes are not. As Beermann has shown in the salivary gland chromosomes, the bands affected (or the chromomeres of the zone concerned) are unrolled and pulled out into separated threads to produce the ring of Balbiani. And this is also the process of the formation of the lateral loops of the lampbrush chromosomes, if the observation of Callan of a reverse relationship between the chromomeric volume and loop length is correct, and there seems little reason to doubt it. Srivastava and Bhatnagar (52) have shown that, in the lampbrush chromosomes of *Rana cyanophlyctis*, when the lateral loops are fully developed the chromomeres are hardly observable, but in the more condensed chromosomes of later stages, which are devoid of the lateral loops, the chromomeres are conspicuous entities. However, there is one important distinction between the active zones of the lampbrush chromosome and those of the salivary gland chromosomes. The activity in the former results in the replication of DNA besides the production of ribonucleoprotein by the active DNA of the zone (14, 38, 39, 58), so that the total DNA at the active locus is several times the amount originally present, whereas no replication of DNA seems to occur at the lampbrush-chromosome locations. Some investigators (Plaut, Gall, Brenner, 58) appear to doubt that the observations of Pavan actually indicate that the genes of the active location in the salivary gland make more DNA, but this scepticism seems neither necessary nor justified. Since different chromosomal zones are involved in the differentiation of the various tissues and organ systems and preside over the physiological functions of the different organ systems, it is obvious that DNA molecules of these several zones differ basically in constitution and may become active at different times in different loci. So it is possible to think that there are two kinds of asynchrony, one in time and another in space, but essentially there is only a polytenisation process, as Plaut (58) thinks. However, Pavan's work shows that an entire set of chromosomes may become inactive and not only particular zones in particular giant chromosomes. And it is not shown that all the bands in any one type of cell synthesize the additional quota of DNA, which is necessary for complete polytenisation. It seems definitely indicated that this massive synthesis of DNA by the activated genes of particular loci is not an indication of ploytenisation, which affects different loci in a temporal sequence, but is somehow associated with the functioning of the cell. This is indicated by the synthesis of RNA by the active bands. In this connection it is also necessary to remember that the polytene chromosomes occur in cells which are fully differentiated and specialized and have lost their capacity for division. It is quite possible that the strict genetical control over the genic duplication of DNA is relaxed in such cells and the synthesis of the additional quota of DNA may be resulting from that. Such a relation will naturally affect only the loci which are most active. Plaut (58) suggests that perhaps one can distinguish between a locus at which the DNA is metabolically active and one where DNA synthesis is no longer controlled. This assumption is not necessary, and one does not have to suppose that in some parts, perhaps in the heterochromatic regions only, the control is relaxed. In differentiated and specialized cells, only certain locations are found to be active and the relaxation of control is naturally manifested in the case of such active genes only.

If Ris's (43,44,28) observations are correct, the loops as well as the chromonema of diakinetic bivalents are composed of microfibrils about 500Å in width, which means that every microfibril is composed of about 25 DNA chains. It must be emphasized, however, that although Ris thinks that the microfibrils are the units of chromosome architecture, the structural unit during mitosis is the chromatid (or sub-chromatid) and the existence of microfibrils furnishes no more clue to the organization of the structural units, chromatids and sub-chromatids, than the concept of polyteny in the sense of packing of numerous and variable DNA-protein molecules. Inci-

dently, it is better to reserve the term polyteny for describing multitude-stranded chromosomes like the salivary gland chromosomes of the dipteran larvae than for expressing the idea of every chromosome being composed of numerous DNA molecules packed in a bundle, for obviously the giant chromosome has a special type of structure.

It is unlikely that the loops have a special constitution of pure ribonucleo-protein, even if they are continuous with the main chromonema, and represent the entire additional material acquired by the chromosome during growth, as Ris thinks. This assumption is also not required, for all the additional material associated with the loops of the lampbrush chromosomes are secondarily synthesised and the chromonema itself does not seem to grow. Longitudinal growth of chromosomes, supposed or real, in somatic cells, is a different matter, for these cells are off the germ-track, which makes a difference.

It is not necessary to consider the idea that the salivary-gland chromosome bands are not constant and do not indicate genetical constancy (29). This has been shown to be unjustified (3-11). The chromomeres of the leptotene threads and lampbrush chromosomes are found to be constant in structure and position, wherever it is possible to ascertain this.

Watson and Crick model allows for the replication of DNA by DNA molecules themselves. Plaut and Mazia's work (40) seems to throw considerable doubt on this mechanism and even Taylor's finding (56) which is basically different from Mazia's, does not support fully the idea of self-replication by DNA molecules. If DNA cannot synthesise itself directly, then it must be doing so through RNA or proteins, of which there does not seem to be any valid indication at present. Thus, there is a great paucity of experimental evidence on the mechanism of synthesis of DNA and investigation of this must claim a good deal of attention in future.

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SECTION OF PHYSICAL SCIENCES
ABSTRACTS OF PAPERS

1. Effect of Dielectric Constant on Ultrasonic Absorption in Electrolytes

S. K. Kor *and* G. S. Verma, *Dept. of Physics, Allahabad University, Allahabad*

Prompted by the recent findings of F. H. Fisher (*Proc. Acoust. Soc. Meeting,* Oct. 20-22, 1960, San Francisco, California) on the effect of varying dielectric constant on the relaxation frequency in $MgSO_4$ at higher concentrations (0·5M) which are exactly opposite to that observed by Bies for lower concentrations ($< 0·02$ M) and also with a view to settle the issue, we have carried out measurements for 0·5M $MnSO_4$ solutions. Results will be presented and its effect on the reaction mechanism will be discussed.

2. Ultrasonic Absorption due to Relaxing Compressibility in Binary Liquid Mixtures

G. S. Verma *and* S. K. Kor, *Dept. of Physics, Allahabad University, Allahabad*

An expression for the excess sound absorption has been obtained for binary liquid mixtures which exibit an excess absorption which is many fold greater than that of either of the two components. The relaxational compressibility is considered to be the predominant cause of excess absorption where a pronounced volume change takes place on mixing of the two components. Theoretical results will be presented for the mixtures in which the two components form strong hydrogen bonds or held together as dipole pair and compared with the experimental results.

3. Dipole-Dipole Interaction in Diluted Paramagnetic Crystals

Prem Swarup, *J. K. Institute of Applied Physics, University of Allahabad, Allahabad*

The spin-spin relaxation times have been calculated on the basis of purely dipole-dipole interactions in crystals containing various concentrations of the paramagnetic triply charged chromium ions. In case of highly dilute crystals, which are normally used in Masers, the paramagnetic resonance lineshapes are Lorentzian and the relaxation times are found to vary linearly with concentration. The experimentally observed data at 9200 Mc in potassium cobalticyanide crystals containing various concentrations of chromium agree with the theoretical values at temperatures where the monitoring microwave power does not start saturation.

4. Work-Function and Surface Transmissions Coefficient for Secondary Electron Emission

S. P. Khare *and* S. N. Ghosh, *J. K. Institute of Applied Physics, University of Allahabad, Allahabad*

It is shown that for secondary electrons having energy upto about 25 ev, produced by bombardment of particles (ions, electrons and neutral atoms) the work-function is smaller compared with the work-functions which thermions and photoelectrons have to overcome. The reduced work-function has been used to calculate surface transmission coefficient of secondary electrons from metal surfaces to the vacuum. The numerical calculations have been carried out for metallic sodium, and the results are applied to explain qualitatively certain features of secondary electrons emission.

5. Vibrational Spectrum and Specific Heat of Potassium

S. K. Joshi *and* M. P. Hemkar, *Department of Physics, Allahabad University, Allahabad*

Bhatia's three force constant model has been utilised to compute the normal modes of vibration of potassium. The dispersion curves are plotted and the frequency spectrum is deduced by Houston's method. The specific heat is computed at various temperatures from the computed vibration spectrum and compared with the experimental data. The variation of the calculated values of the Debye temperature also studied.

6. Absoption Spectrum of ZnI Molecule in the Ultraviolet Region

K. C. Joshi *and* K. Majumdar, *Physics Department, University of Allahabad, Allahabad*

Out of the five band systems, which have been reported for the molecule ZnI, only one, *viz.,* B—X is known to occur in absorption. In this investigation the C—X system has been observed in absorption. By heating ZnI in a vacuum graphite tube furnace, eleven bands have been observed in the region $\lambda\lambda 3415 - 3264$, which include two new bands not reported before. The following formula represents well all the bands :—

$$\nu_{v'v''} = 30117 \cdot 6 + 248 \cdot 2 \ (v' + \tfrac{1}{2}) - 0 \cdot 70 \ (v' + \tfrac{1}{2})^2 - 223 \cdot 4 \ (v'' + \tfrac{1}{2}) + 0 \cdot 75 \ (v'' + \tfrac{1}{2})^2.$$

7. Controlled Reaction between Active Nitrogen and Methylene Chloride

S. N. Ghosh, A. Sharma *and* Sarda Nand, *J. K. Institute of Applied Physics, University of Allahabad, Allahabad*

Controlled reaction between active nitrogen and methylene chloride is performed in a dynamical flow system. The nitrogen is activated by microwave discharge from an oscillator operating at a frequency of 2450 Mc/sec. The spectrum of N_2 shows the first and second positive systems of N_2, first negative system of N_2^+ and some atomic lines. The spectrum shows red and violet systems of CN and one band of CH at 4312 A. The intensity variation of two CN bands with the partial pressure of CH_2Cl_2 is photometrically studied and the cross-section of quenching of excited CN by CH_2Cl_2 is found to be $3 \cdot 5 \times 10^{-15}$ cm^2.

The mass-spectrometric and infra-red analyses of the gas taken from the region where glow occurs shows HCl as one of the final products of the reaction. The mechanism of the reaction is discussed.

8. Enhancement of D-layer Ionization

S. N. Ghosh *and* Sarda Nand, *J. K. Institute of Applied Physics, University of Allahabad, Allahabad*

The enhancement of D-layer ionization due X-rays of wavelengths less than 10A has been calculated and its rate of production is found to be 100 and 38 ions cm^{-3} sec^{-1} in the altitude range 80-100 Km and 60-80 Km respectively. Assuming

the enhanced ionization, in the D-layer equals the normal ionization, the concentration of NO has been computed and compared with the values obtained by other investigators (Nicolet, 1955, Miller, 1957).

9. Exciting Particles for Auroral Spectra

B. N. Srivastava *and* S. N. Ghosh, *J. K. Institute of Applied Physics, Univ ity of Allahabad, Allahabad*

In this paper, the excitation of auroral spectra has been discussed in the light of laboratory excitation of the spectra of atmospheric gases by electron, proton and H atom bombardments, and the penetration of these particles through the atmosphere. It is concluded that in normal aurora 1st negative band of N_2^+ and O_2^+ are produced by proton bombardments. OI lines in aurora have features common with these lines in proton-induced spectra. It cannot be definitely said that OII lines are produced either by proton or electron bombardment. Permitted lines of NI and NII, and forbidden lines of NI are excited during ionization of N_2 molecules followed by dissociation by proton and electron bombardments, and dissociative recombination of N_2^+ ions with electrons respectively. Laboratory evidences indicate that low attitude aurorae are produced by secondary electron bombardments.

10. The Mass-frequency Function in Galactic Clusters

O. P. Gupta *and* R. S. Kushwaha, *Department of Astronomy and Astrophysics, University of Delhi, Delhi-6*

An important question in present day astronomy is the distribution of stars in different masses called the mass-frequency function. For a system like neighbourhood of Sun or stars in a large volume of galaxy, the whole steller-population may not have been born at the same time and, therefore, the present mass-frequency function may be a combination of different mass-frequency functions of stars at the time of their births. In the present work an attempt has been made to study the observed mass-frequency function of a group of stars which is believed to be born at the same time. Most probably galactic clusters represent such system. It is assumed that the birth of all the stars comes about as a single event. Theory of random-fragmentations can be applied to these systems. The theoretical mass-frequency function has been compared with the observed one in case of several galactic clusters. The two are found in reasonable agreement.

These galactic clusters being very young, it is found that evolution does not have any appreciable effect on these distributions. The linear representation of mass-frequency function in logarithmic variables as assumed by previous workers appears to differ from the observed mass-frequency function towards the low mass end. There is definitely a curvature in the observed curve. A parabola, therefore, is fitted with the help of least square solution. It is found that it represents the observed curve fairly well in the whole range. From the comparison of the observed curve with the theoretical curve for random fragmentation, the original masses of the various clusters are estimated. They are found to be of the right order.

II. The Preparation of Stannic Succinate Gel by Metathetic Process

R. P. Gupta *and* S. P. Mushran, *Chemical Laboratories, University of Allahabad, Allahabad*

The addition of sodium succinate to stannic chloride solution gives a white gelatinous precipitate. If the amount of sodium succinate added is less than the precipitating value a clear solution is obtained, which when left undisturbed sets to a firm and stable gel. Interaction of $0.5M$ stannic chloride and sodium succinate of the same concentration gives gels for which the gelling time ranges from 25 to 329 minutes. Freshly prepared gels are translucent in nature but have a tendency to become opaque on standing.

12. Study of the V^{iv} Precipitates by Physico-chemical Methods, Part I : Electrometric Study of Vanadyl Ferrocyanide

P. K. Bhattacharya *and* S. N. Banerji, *University of Saugar, Saugar*

The reaction between vanadyl sulphate and potassium ferrocyanide has been studied by the application of monovariation method in two ways. In the first case the volume of vanadyl sulphate was kept constant and that of equimolar potassium ferrocyanide varied. In the latter case the volume of potassium ferrocyanide was kept constant varying that of equimolar vanadyl sulphate.

Electrometric measurements were carried on using $M/40$ and $M/60$ solutions each of vanadyl sulphate and potassium ferrocyanide. The experimental curves in both the cases indicated a break nearly corresponding to the formation of vanadyl ferrocyanide $(VO)_2[Fe(CN)_6]$. It was, however, seen that the equivalence point does not exactly correspond with the theoretical values of the solutions required. In the first case the volume of the solution required is slightly less and in the second case slightly more than the theoretical values.

The experiments, when repeated in presence of 10% and 20% alcohol, show that the volumes of solutions required gradually approach the theoretical values. It is clear, therefore, that the discrepancy between the observed and theoretical values is due to (*i*) the greater adsorption of VO^{++} ions by vanadyl ferrocyanide and (*ii*) its hydrolysis.

13. Study of the V^{iv} Precipitates by Physico-chemical Methods, Part II : Electrometric Study of Vanadyl Ferricyanide

P. K. Bhattacharya *and* S. N. Banerji, *Department of Chemistry, University of Saugar, Saugar*

The precipitation of vanadyl ferricyanide has been studied electrometrically by means of monovariation method in two ways (*i*) taking constant volume of vanadyl sulphate and varying that of equimolar potassium ferricyanide and (*ii*) *vice versa*.

The electrometric measurement data in case of $M/40$ and $M/60$ solutions, when plotted indicated the formation of vanadyl ferricyanide $(VO)K[Fe(CN)_6]$. It was, however, seen that in the first case the volume of $K_3Fe(CN)_6$ required is less than the equimolar vanadyl sulphate, whereas in the second case the volume of vanadyl sulphate required is more.

The above experiments, when performed in presence of 10% and 20% alcohol bring a better agreement between the theoretical and observed values, showing thereby that the discrepancy may be due to the greater adsorption of VO^{++} ions by vanadyl ferricyanide and its hydrolysis to liberate $[Fe(CN)_6]^{3-}$ ions.

14. Physico-chemical Study of the Insoluble Compounds of Trivalent Cerium, Part I : Electrometric Study of Cerous Molybdate

M. C. Saxena *and* A. K. Bhattacharya, *Department of Chemistry, University of Saugar, Saugar*

The precipitation of cerous molybdate from cerous chloride and sodium molybdate has been studied electrometrically using the monovariation method in two ways, (i) keeping the concentration of Ce^{+++} ions constant and varying that of MoO_4^{--} ions and (ii) *vice-versa*.

The conductometric study in both the ways was carried out using equimolecular solutions of the reactants at three different dilutions, *viz.*, M/30, M/40 and M/60. The experimental curves exhibit only one break nearly corresponding to the formation of normal cerous molybdate, $Ce_2(MoO_4)_3$.

It was observed in each case that the point of equivalence did not occur at the theoretical value. Thus the precipitation of cerous molybdate required a lesser amount of cerous chloride in the first case, and greater of sodium molybdate in the second case, as compared to the calculated equivalent amounts. To find out whether this discrepancy was due to the hydrolysis of the precipitated cerous molybdate or due to unequal adsorption of cerous and molybdate ions by the precipitate, the above experiments were repeated in the presence of two different concentrations of alcohol, namely, 10% and 20%. The presence of alcohol did not bring about a closer approximation between the calculated and observed values, and hence it was assumed that the difference in the two values was due to a greater adsorption of Ce^{+++} ions than of MoO_4 ions by the precipitated cerous molybdate.

In the case of pH study the experiments were performed in the same way as described above. The results of the pH measurements were found to be in complete accord with those of conductance measurements.

The composition of the precipitate was also confirmed by estimating analytically the cerium and molybdate contents in it.

15. Physico-chemical Study of the Insoluble Compounds of Trivalent Cerium, Part II : Electrometric Study of Cerous Tungstate

M. C. Saxena *and* A. K. Bhattacharya, *Department of Chemistry, University of Saugar, Saugar*

The precipitation of cerous tungstate has been studied electrometrically by means of the monovariation method in two ways. In the first case cerous chloride was the constant component and sodium tungstate was the variable one, whereas in the second case the volume of sodium tungstate was kept constant varying that of cerous chloride.

Electrometric measurements of the system using M/40 and M/60 solutions, each of cerous chloride and sodium tungstate revealed that normal cerous tungstate, $Ce_2 (WO_4)_3$ is formed on mixing the two reacting solutions. It was, however, seen that the point of equivalence did not occur at the calculated value. In the first case a lower experimental value, whereas in the second case a higher value was obtained.

The above experiments, when repeated in the presence of 10% and 20% alcohol, respectively, showed that the presence of alcohol does not affect the position of the equivalence point. This indicated that the difference in the experimental and theoretical values should not be due to the hydolysis of the precipitated cerous tungstate. The difference could, however, be explained on the assumption that cerous tungstate adsorbs more Ce^{+++} ions than WO_4^{--} ions.

16. Studies on the Solubilising Action of Quaternary Ammonium Group on certain Organic Reagents and their Metal Complexes

N. K. Mathur *and* J. N. Gour, *Department of Chemistry, University of Rajasthan, Jaipur*

The syntheses of certain organic reagents containing vic-dioxime N-hydroxy-triazene and hydroxy-oxime groups have been described. The reagents under investigation contain an additional solubilising quaternary ammonium group [$-N^+(CH_3)_3Cl^-$] and yield with certain metal ions soluble complex cations rather than the usual precipitate. Two general methods have been used for introducing such groups in the molecules of organic reagents. In one of the methods the original reagent containing tert-amino group is reacted with methyl iodide while in the second method the reagent is subjected to chloromethylation followed by reacting with trimethyl amine. This property has been utilised in preparing colour reagents suitable for spectrophotometric analysis. The properties of the reagents are compared with the parent precipitants and it has been shown that just like the sulphonic acid group the quaternary amino group also does not change the chelating properties of the organic reagents and the suitability of such group for solubilising metallo organic complexes has been established.

17. Salt Effect in the Silver Catalysed Oxidation of Oxalic Acid by Potassium Persulphate

C. D. Bisht *and* S. P. Srivastava, *Chemical Laboratories, D. S. B. Government College, Nainital*

The study of the salt effect for the silver catalysed oxidation of oxalic acid by persulphate has been investigated at low ionic strengths. Minute traces of sulphuric acid have been found to catalyse this reaction. At the low concentrations employed (0·005M) the induction period is found to disappear almost completely and the extent of autocatalysis is also found to decrease considerably. The reaction with oxalic acid is slightly slower than with sodium oxalate at the same ionic concentration, the difference in the rate is not much.

The salt effect has been investigated by the addition of sodium sulphate and potassium sulphate as neutral salts. In both the cases it is found that the salt effect is negative and of the primary exponential type. This suggests that the rate determining process is between two oppositely charged ions.

18. Kinetics of Oxidation of Acetaldehyde in Aqueous Solution by Potassium Persulphate, Part I
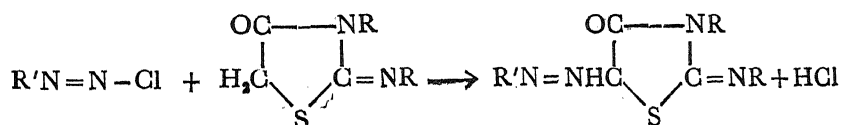
K. C. Khulbe *and* S. P. Srivastava, *Chemical Laboratories, D. S. B. Government College, Nainital*

The kinetics of the Ag^+ catalysed oxidation of acetaldehyde in aqueous solution by potassium persulphate has been investigated. The reaction is found to be unimolecular in behaviour ; the rate being directly proportional to the concentration of persulphate ion and Ag^+ ion. The rate is however, almost independent of the concentration of acetaldehyde. The temperature coefficient and thereby the energy of activation, frequency factor and the entropy of activation have been calculated. Ferrous sulphate is found to be ineffective as a catalyst for this reaction.

19. Preparation of Some 5-arylazo-3-aryl-2-aryliminothiazolid-4-ones

Ravindra Pratap Rao, *Department of Chemistry, University of Gorakhpur, Gorakhpur*

The preparation of a number of 5-arylazo-3-aryl-2-aryliminothiazolid-4-ones has been described. These compounds have been prepared by coupling diazotised amines with the appropriate thiazolid-4-ones. Their formation takes place as follows :

$$R'N=N-Cl \ + \ H_2C \underset{S}{\overset{OC---NR}{\diagup\diagdown}} C=NR \longrightarrow R'N=NHC \underset{S}{\overset{OC---NR}{\diagup\diagdown}} C=NR+HCl$$

These compounds have been prepared in order to observe the effect of the introduction of azo group in the parent compounds, on their fungicidal activity, in view of the fact that their introduction considerably enhances the antibacterial activity.

20. Thioindigoid Dyes from 3-arylthiazolid-2, 4-diones : The [indol-(3)]-[3-aryl-2, 4-diketo-thiazolidine-5]-indigos

Ravindra Pratap Rao, *Department of Chemistry, University of Gorakhpur, Gorakhpur*

A number of thioindigoid dyes derived from 3-arylthiazolid-2, 4-diones have been described. These dark coloured compounds have been obtained by condensing 3-arylthiazolid-2, 4-diones with isatin in glacial acetic acid medium (containing some acetic anhydride) in presence of anhydrous sodium acetate. The formation of these compounds proceeds along the lines indicated below :

$$\text{[indol ring]}\overset{CO}{\underset{CO}{\diagup}} \ + \ H_2C \underset{S}{\overset{OC---NR}{\diagup\diagdown}} CO \longrightarrow \text{[indol ring]} C=C \underset{S}{\overset{OC---NR}{\diagup\diagdown}} C=O \ + \ H_2O$$
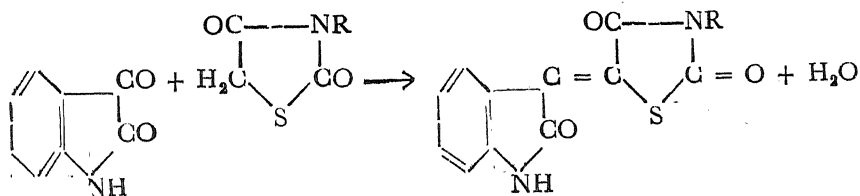
21. Preparation of Some 5-aryl-3-aryl-2-aryliminothiazolid-4-ones

Ravindra Pratap Rao, *Department of Chemistry, University of Gorakhpur, Gorakhpur*

The preparation of seven 5-aryl-3-aryl-2-aryliminothiazolid-4-ones has been described. The thiazolidones were treated with diazotised amines and the diazo compounds formed are decomposed with splitting of nitrogen, yielding the desired compouds.

$$R'N = NHC\underset{S}{\overset{OC-----NR}{\diagdown\diagup}}C=NR \longrightarrow R'HC\underset{S}{\overset{OC-----NR}{\diagdown\diagup}}C=NR + N_2$$
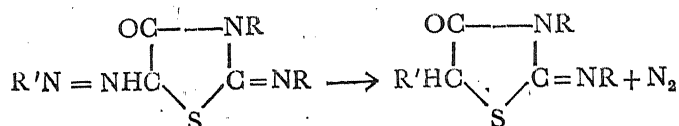
These compounds have been prepared in order to study the effect of the introduction of lipophilic groups on the fungicidal activity of the parent compounds.

22. Equilibrium Potassium Adsorption Ratio of Soils in Relation to the Availability of Soil Potassium

B. Rama Moorthy *and* K. V. Paliwal, *Division of Chemistry, Indian Agricultural Research Institute, New Delhi*

The chemical determination of what constitutes available potassium is very important to agriculture. As reported in literature, none of the soil tests studied correlated with the availability of potassium as measured by response of paddy to the application of potash on Raipur, Dumka, Raneshwar and Mangalore blocks consisting in all 40 soils from the three states in India. That these constituted a very heterogeneous soil population as regards their colloidal characteristics is seen from the fact that both the exchangeable K (Ex. K) and the degree of potassium saturation ranged from 0·46 to 2·41 and 4·77 to 24·4 respectively in the soils when they were brought into equilibrium with one and the same standard solution containing Ca + Mg + K at 12 me./litre as total strength and a potassium adsorption ratio (K. A. R.) of $2·43 \times 10^{-2}$. The above soil tests with Morgan's extractant, 1% citric acid, 0·5N HNO_3 either with or without heating and N ammonium acetate ded not therefore measure the availability of K irrespetive of soil factors.

According to the Ratio Law in cation exchange in soils, the escaping tendency of soil K from the clay phase is determined only by the K. A. R. of the soil solution. Thus each of many solutions with varying K-ion activity, can keep the K of the clay phase intact so long as in each case the K. A. R. of the solution is the same as before which is then equal to a similar function of the exchangeable cations and is called the equilibrium K. A. R. of the soil. From the Ex. K present in the soil both in the natural condition and after bringing them into equilibrium with the standard solution and by assuming a linear relationship between Ex. K and K. A. R. of the equilibrium solution in the limited range of the latter from 0 to $2·5 \times 10^{-2}$, the value designated as K. A. R. (calculated) of the soils has been determined.

This value was found to correlate with crop responses in all the four blocks both together and separately at 1% level of statistical significance in all cases

excepting the Raneshwar block wherein it was at 2% level of significance. Thus the K. A. R. calculated of the soils seemed to have wider applicability than the conventional soil tests in soils of widely varying physico-chemical characteristics.

23. Quality of Irrigation Water

C. L. Dhawan *and* P. D. Ghai, *Irrigation and Power Research Institute, Punjab, Amritsar*

A comparison of the different standards being in vogue in different countries for judging the quality of irrigation water has been made and thus the comparative correctness of the different standards has been brought out.

24. Reclamation of Alkali Soils by Argemone Mexicana and Ipomea

C. L. Dhawan, P. D. Ghai *and* Ved Parkash, *Irrigation and Power Research Institute, Punjab, Amritsar*

An attempt has been made to study both in the laboratory and semifield the comparative efficiency of Argemone Mexicana and Ipomea on the reclamation of alkali soils. Titration curves with standard sodium hydroxide and high pH soil were determined. Rice was tried in the semifeld plots treated with these plants. It was inferred that Ipomea behaved better than Argemone Mexicana.

25. Reclamation of Alkali Soils by Coal

C. L. Dhawan, P. D. Ghai *and* Ved Parkash, *Irrigation and Power Research Institute, Punjab, Amritsar*

The efficiency of processed Assam coal received from Fuel Research Station was investigated in the laboratory and on semifield scale. On the basis of the results of titration curves with standard sodium hydroxide and high pH soil and the results of semifield experiments it was concluded that processed Assam coal could be used for the reclamation of alkali soil to some extent. The effect of some types of charcoals prepared from different sources has also been studied.

26. Shear Characteristics of Soils

C. L. Dhawan *and* R. N. Sharma, *Irrigation and Power Research Institute, Punjab, Amritsar*

An empirical equation between the angle of internal friction and the different size particles of soil has been determined. The experimental values of angle of internal friction and those determined from the formula show a close agreement.

27. Classification of Soils

C. L. Dhawan, *Irrigation and Power Research Institute, Punjab, Amritsar*

An attempt has been made to classify the soils on the basis of surface area. It has been observed that surface area of soils goes a long way in defining the different properties of soils *i. e.* base exchange, water holding capacity, plastic index, etc.

2

28. Mixed Mesomorphism

J. S. Dave *and* J. M. Lohar, *Chemistry Department, Faculty of Science, M. S. University of Baroda, Baroda*

A number of binary systems have been investigated with p-azoxyanisole as a liquid crystalline component and another arbitrary normal solute. It is observed that (*i*) mixed liquid crystals will always be formed over a certain minimum area irrespective of the shape, size and structure of the solute molecules, (*ii*) dissimilarity in the molecules of the two components causes a difficulty in the packing of the molecules together resulting into a concavity of the transition lines which increases to a minimum with increased mesomorphic tendency of the non-liquid crystalline component and (*iii*) contribution of the central group towards the mesomorphic tendency of the non-liquid crystalline component seems to be negligible.

29. Iodimetric Estimation of Small Amounts of Formates Involving Oxidation by Mercuric Chloride

R. M. Verma *and* Sameer Bose, *Mahakoshal Mahavidyalaya, Jabalpur*

A specific method applicable in presence of salts of other organic acids, is described for volumetric estimation of small amounts of formate ion. The procedure can be adopted for evaluating 1 to 40 mgm. of formic acid with a precision of 1% or more. It involves oxidation of neutral formate salts by hot mercuric chloride solution and the calomel formed is determined by treating with excess of potassium iodide and iodine solution. Salts of acetic, butyric, citric, tartaric, benzoic, boric, adipic and oxalic acids were not found to interfere with the present procedure.

30. Adsorption of Congo Red by Hydrous Thorium Oxide

Rameshwar Prasad *and* Arun K. Dey, *Chemical Laboratories, University of Allahabad, Allahabad*

Four samples A, B, C and D of hydrous thorium oxide were precipitated by the interaction of solutions of thorium chloride with (*i*) 10% deficient, (*ii*) equivalent, (*iii*) 5% excess and (*iv*) 10% excess of sodium hydroxide, respectively. The order of adsorption of Congo Red with the samples was found to lie in the sequence: A > B > D > C. It was further observed that the adsorptive capacities of these samples at 30°, 40° and 50° follow the same order, but decrease with rise in temperature due to ageing. The results have been explained on the basis of amphoterism of the hydrous oxide and it has been suggested that sample C is isoelectric in nature.

31. Chelate Formation between Copper (II) and Sulpho-dichloro-hydroxy-dimethyl fuchson dicarboxylic Acid

Suresh Chandra Srivastava *and* Arun K. Dey, *Chemical Laboratories, University of Allahabad, Allahabad*

Bipositive copper has been reported to form a violet coloured chelate (λ_{max} 580 mμ) in solution, with sulpho-dichloro-hydroxy-dimethyl fuchson dicar-

boxylic acid (trisodium salt; commonly known as Chrome Azurol S). The colour reaction is extremely sensitive and is useful in the colorimetric determination of bivalent copper. Spectrophotometric and electrical conductance studies have been performed and the composition of the chelate has been found to be 1:1. The methods employed have been the method of continuous variation (using absorbance and electrical conductance measurements), the slope ratio and the mole ratio methods (using absorbance measurements).

The characteristics of the reagent, have also been investigated and it has been found to behave as a colloidal electrolyte.

The value of log K, as determined by the method of Dey *et al* and by the mole ratio method work out to be $4·0 \pm 0·1$ and $4·2 \pm 0·1$ respectively, at 30° and at pH 6·5 and ionic strength 0·1 ($NaClO_4$).

32. Chelate Formation of Tripositive Iron with Sulpho-dichloro-hydroxy-dimethyl fuchson dicarboxylic Acid

Roshan Lal Seth *and* Arun K. Dey, *Chemical Laboratories, University of Allahabad, Allahabad*

Chelate formation between tripositive iron and the reagent Chrome Azurol S has been investigated by the method of continuous variation (using absorbance and electrical conductance measurements) and by the slope ratio and mole ratio methods (using absorbance measurements). The composition is found to be 1:1. The chelate has a λmax at 570 mμ beetween pH 3·0 to 5·5.

The value of log K by two different methods works out to be $4·8 \pm 0·1$ at 25°.

33. Separation of Titanium and Zirconium by Solvent Extraction

Kailash Nath Munshi *and* Arun K. Dey, *Chemical Laboratories, University of Allahabad, Allahabad*

The separation of titanium (IV) and zirconium (IV) has been effected from a mixture of their aqueous solutions, by using a solution of cupferron in butanol. The mixture is thoroughly shaken with the cupferron solution and titanium-cupferron complex is extracted completely by butanol, leaving zirconium in the aqueous layer. It has been found that the separation is quantitative and the two metals can be estimated in the respective layers.

34. Separation and Identification of Micro-Quantities of Metalic Ions by Ring Oven Technique

Eric John Singh *and* Arun K. Dey, *Chemical Laboratories, University of Allahabad, Allahabad*

A simple micro-analytical method for the separation of metallic ions of the same group of qualitative analysis, using citrate as a complexing agent, has been developed, using the Ring Oven Technique. It is found that, in general, the

addition of the complexant is necessary for a good separation. The complete separation and identification of an individual group of elements can be made within five minutes.

35. Chromatographic Separation of some Ions Using Aqueous Ethanol as Solvent

Shib Das Biswas *and* Arun K. Dey, *Chemical Laboratories, University of Allahabad, Allahabad*

The attempted separation of Fe (III), Al (III) and Cr (III), by ascending filter paper strip chromatography, using aqueous ethanol as solvent has been described. Details for good separation of these in mixtures have been worked out.

36. Murexide (Ammonium Purpurate) as an Indicator in Thorium—EDTA Titrations

Satendra Prashad Sangal *and* Arun K. Dey, *Chemical Laboratories, University of Allahabad, Allahabad*

The use of ammonium purpurate (Murexide) as an indicator in the complexometric determination of thorium with ethylenediamine tetraacetic acid has been described. Titrations are possible at all temperatures upto a dilution of 0·005M of thorium at a pH of 2·5. Many of the anions and cations are observed to interfere, except the alkali and alkaline earth metals, silver (I), mercury (II), aluminium (III), arsenic (III) and manganese (II). Estimation of thorium in the presence of iron (III) has been possible by masking the latter with ascorbic acid.

37. Colorimetric Determination of Tungsten (VI) with Sodium Alizarin-3:Sulphonate as a Chromophoric Reagent

Surendra Nath Sinha *and* Arun K. Dey, *Chemical Laboratories, University of Allahabad, Allahabad*

A method for the colorimetric determination of hexavalent tungsten, using Alizarin Red S has been described. The composition of the chelate is MKe_2 and λ_{max} lies at 470 mμ. The colour reaction is instantaneous. The coloured complex adheres to Beer's law over a range 7·5 to 37 p. p. m. of tungsten. The suitable pH for the measurements is 3·5 to 5·8, and temperature has no effect of the intensity of colour. The sensitivity is 0·037 γ/cm^2 (Sandell) and 0·37γ/cm^2 (practical). Many of the common ions are observed to interfere.

38. Studies on Molecular Associations Involving H-bond, Part I

Sarvagya S. Katiyar, *Department of Physical Chemistry, National Sugar Institute, Kanpur*

The studies on H-bond, intermolecular or intramolecular have been a subject of recent interest. Bhagwat and coworkers have recently employed parachor, for the detection of H-bond, in various binary mixtures known to be having H-bond have been carried out with a view to detect hydrogen bonding by employing

parachor method. The components of ester-alcohol and amine alcohol mixtures investigated in the present study were such that they differed in their surface tensional values by less than 7 dynes cm⁻¹. The following mixtures were studied :

    (*i*) Ethyl acetate, methyl acetate and ethyl formate in alcohols (methyl to butyl).

    (*ii*) Toluene and cyclohexane in alcohols methyl to octyl (leaving heptyl).

    (*iii*) Ethyl benzoate, methyl salicylate, aniline o-toluidine, dimethyl aniline and pyridine in benzyl alcohol

It has been shown that the parachor values of the solutes in the above binary mixtures as determined by the actual experiment and as calculated by the mixture law of Hammick and Andrew are almost indentical. For example in alcohols (methyl to butyl) the calculated values of parachor of methyl acetate and ethyl acetate were 178·0 (experimental 177·7) and 217·0 (experimental 216·7) respectively. These results indicated that evidence for the presence of H-bond in such mixtures cannot be deduced from parachor studies.

39. Studies on Molecular Associations Involving H-bond, Part II

Sarvagya S. Katiyar, *Department of Physical Chemistry, National Sugar Institute, Kanpur*

The phenomenon of intermolecular association resulting in the development of a few unusual properties in the system is generally ascribed to H-bond formation. The present investigations were carried out to examine the applicability of parachor method for the detection of H-bond in binary mixtures manifested with H-bond. The following systems with components differing in surface tensional values by more than 7 dynes cm.⁻¹ were investigated.

    (*i*) Ethyl benzoate and methyl salicylate in alcohols (methyl to butyl).

    (*ii*) Aniline, o-toluidine, dimethyl aniline in alcohols (methyl to butyl).

    (*iii*) Ethyl acetate, methyl acetate and ethyl formate in benzyl alcohol.

    (*iv*) Anisole, acetophenone, pyridine, quinoline in chloroform.

It has been observed that for a number of mixtures the value of the parachor of solute when calculated from Hammick and Andrew's mixture law is lower than its separately determined parachor value. This lowering may be attributed to the presence of H-bond. But because of some exceptions observed in the present investigations and many others recorded in the literature, the difference between the observed parachor values and actual values can conclusively not be attributed to hydrogen-bonding.

40. Studies in Chromium Arsenite sol, Part II : Effect of Temperature and Dilution on the Viscosty and Conductivity of the Sol at Various Stages of Dialysis

P. C. Jain *and* S. N. Banerji, *Department of Chemistry, University of Saugar, Saugar*

Observations show that in the case of impure sol the viscosity decreases with increase of temperature. However, in the purified sol the decrease is followed by an increase. Similar behaviours have been noted in the values of *q*. This may be due to the formation of loose aggregates at higher temperatures.

It is interesting to note that when the sols are diluted the viscosity at all stages of purity decreases with the increase of temperature. Hence it may be assumed that the tendency of the particles to form loose aggregates is lost on dilution. The specific conductivity of the sol decreases on dilution. The temperature of zero conductance lies between $-20°C$ to $-30°C$; and the temperature coefficient of conductivity has a value in between 1·5% and 2·5% per degree rise of temperature to the value at 30°C.

41. Studies in Chromium Arsenite Sol, Part III : Changes in Extinction, pH and Electrical Conductivity of the Sol during Coagulation under Different Stages of Dialysis

P. C. Jain *and* S. N. Banerji, *Department of Chemistry, University of Saugar, Saugar*

Extinction measurements show that coagulation of the sol is accelerated with the addition of increasing amounts of electrolyte and a constant maximum flocculation is reached. At higher concentrations, the extinction begins to decrease due to the formation of loose flocs, that scatter lesser light than those formed at relatively lower concentrations.

With the addition of increasing amounts of K_2SO_4, the pH of the sol increases. This is due to the adsorption of H_3O^+ ions on the partly neutralised colloid surface and consequent increase of OH^- ions concentration in the medium.

There is a continuous decrease in the conductivity of the sol with the progressive addition of the electrolyte. This has been ascribed to the greater penetrating power of SO_4^{--} ions as also their power of neutralising the positive charges of the sol particles, with the result, that they cannot contribute to the total conductivity of the mixture of sol *plus* electrolyte. Moreover, the increased radius of the micelles and the salt-effect also play their roles in decreasing the conductivity of the sol to some extent.

42. Effect of Dilution on the Coagulation of Silver Iodide Sol, Part I

S. S. Uppal *and* S. Ghosh, *Allahabad University, Allahabad*

The effect of electrolytes on the stability of negatively charged silver iodide sols having same concentration of silver iodide and different amounts of the peptising electrolyte potassium iodide has been studied at different dilutions. The amounts of an electrolyte required to coagulate the sol in one hour and infinite time of observation have been graphically determined.

The results show that (i) the amounts of electrolytes potassium nitrate, barium nitrate and aluminium nitrate required for coagulation generally decrease as the sol is diluted and Burton—Bishop rule is not followed; (ii) as the concentration of the stabilising electrolyte potassium iodide is increased in the sol it becomes more stable towards the electrolytes potassium nitrate and barium nitrate and have a tendency to obey Burton—Bishop rule, (iii) the behaviour of the sol on dilution is related with the time of observation. For the electrolytes potassium nitrate and barium nitrate the stability of the dilute sol becomes more when the time of observation is one hour than what it is when the time of observation is infinite, (iv)

the stability of the sol decreases when a very high concentration of potassium iodide is used so that here the coagulating effect of potassium ions from larger amounts of potassium iodide added becomes prominent.

By using Ag(s), AgI(s), I⁻ electrode the adsorption of iodide ions by silver iodide particles has been determined potentiometrically. From the results it is found that the adsorption of iodide ions leading to electric charge on the colloidal surface is guided by the adsorption rule, so that desorption of iodide ions occurs on diluting the sol. It is, therefore, likely that the electric charge on the colloidal particles decreases on dilution making them unstable. This conclusion is further confirmed by the study on the coagulation of silver iodide sol at different temperatures, as described in part II of this series.

43. Effect of Temperature on the Stability of Negatively Charged Sol of Silver Iodide, Part II

S. S. Uppal *and* S. Ghosh, *Allahabad University, Allahabad*

Considering the rate of coagulation as inversely proportional to the time of complete coagulation (t) of a sol, we have

$$\log t = -\log KP\mathcal{Z} + \frac{E}{2\cdot303\,R\,T}$$

where P is the probability or steric factor, $\mathcal{Z}$ the number of collisions per unit time per unit volume, E the energy of activation, R the gas constant, T the absolute temperature and K is the proportionate constant.

The rate of coagulation of negatively charged silver iodide sols peptised by different amounts of potassium iodide has been determined as 30°C, 40°C and 50°C using potassium nitrate, barium nitrate and aluminium nitrate as coagulating electrolytes. It is interesting to note that the plots of $\log t$ against $1/T$ yield straight lines showing the applicability of the above relation for the process of coagulation. The values of the energy of activation are determined from the slopes of the straight lines thus obtained. From the results the following important conclusions are drawn :

(i) The rate of coagulation increases with increasing temperature.

(ii) With increasing amounts of electrolytes used for coagulation the value of E slightly increases and the value of P increases significantly.

(iii) The value of E is slightly affected for the sols of negatively charged silver iodide containing different amounts of the peptising electrolyte potassium iodide free in the sol. It is also slightly changed when the sols are diluted,

On the other hand, the value of P quickly decreases with increasing concentration of potassium iodide free in the sol with the coagulating electrolytes potassium nitrate and barium nitrate and increases with increasing dilution of the sol. This indicates that the value of P or the steric factor decreases with the increasing charge on the colloidal particles.

44. Polarographic Studies of Metal Complexes, Part I. The System:—$ZnSO_4$ — $CS(NH_2)_2$ — KNO_3 — H_2O

A. C. Chatterji *and* J. Prashad, *Chemical Laboratories, Lucknow University, Lucknow*

The $E_{\frac{1}{2}}$ and diffusion current of Zn ion were determined under nitrogen atmosphere each time at $35 \cdot 0 \pm 0 \cdot 1°C$ in solutions containing $0 \cdot 001$ M Zn^{++}, $0 \cdot 1$ M KNO_3, $0 \cdot 0001$M HNO_3 and thiourea in concentrations of $0 \cdot 1$ to $1 \cdot 0$M. Analysis of the data by Hume and DeFord method of mathematical treatment showed the existence of mono- and bis-coordinated species of zinc complexes with thiourea. The respective formation constants were calculated to be $2 \cdot 5$ and $6 \cdot 0$. Effect of change of supporting media and metal ion concentration on the stability of the complexes has also been investigated.

45. Polarographic Studies of Metal Complexes, Part II. The System:—$TlNO_3$ – NaSCN — $NaNO_3$ — H_2O

A. C. Chatterji *and* J. Prashad, *Chemical Laboratories, Lucknow University, Lucknow*

The $E_{\frac{1}{2}}$ and i_d of Tl^+ were determined under N_2 atmosphere each time at $25 \cdot 0 \pm 0 \cdot 1°C$ in mixtures containing $0 \cdot 001$M Tl^+, $0 \cdot 0001$M HNO_3, NaSCN and $NaNO_3$ in concentrations to keep the ionic strength of the medium at (*i*) $2 \cdot 0$ and (*ii*) $3 \cdot 0$M while the concentration of the SCN^- ion was changed from $0 \cdot 1$ to $2 \cdot 0$ and $3 \cdot 0$M respectively. Analysis of the data by Hume-DeFord method of mathematical treatment showed the existence of only unionized TlSCN with a formation constant value of $3 \cdot 20$ (at $\mu = 2 \cdot 0$M) and $3 \cdot 60$ (at $\mu = 3 \cdot 0$M). These results do not agree with those of Hsu and Tsiang and of Sundaram and Vartak. Effect of change of ionic media and metal ion concentration on the stability of the complexes was also investigated.

46. Polarographic Studies of Metal Complexes, Part III. The System:—$TlNO_3$ – $CS(NH_2)_2$ – KNO_3 — H_2O

A. C. Chatterji *and* J. Prashad, *Chemical Laboratories, Lucknow University, Lucknow*

The $E_{\frac{1}{2}}$ and i_d of Tl^+ ion were determined under N_2 atmosphere each time at $35 \cdot 0 \pm 0 \cdot 1°C$ in solutions containing $0 \cdot 001$M Tl^+, $0 \cdot 0001$M HNO_3, $0 \cdot 1$M KNO_3 and thiourea in concentrations of $0 \cdot 1$M to $0 \cdot 6$M. Analysis of the data by Hume-DeFord method of mathematical treatment revealed the existence of the complex Tl [CS $(NH_2)_2$] NO_3 with formation constant of $3 \cdot 0$. Above thiourea concentration of $0 \cdot 6$M, a complex Tl [CS $(NH_2)_2]_4$ NO_3 is precipitated which was found to be more stable than the mono complex of this system. Effect of change of ionic media and metal ion concentration on the stability of the complexes was also investigated.

47. Polarographic Studies of Metal Complexes, Part IV. The System:—$ZnSO_4$ — $(CH_2COOK)_2$ — KNO_3 — H_2O

A. C. Chatterji *and* J. Prashad, *Chemical Laboratories, Lucknow University, Lucknow*

The $E_{\frac{1}{2}}$ and i_d of Zn^{++} were determined under N_2 atmosphere each time at $35 \cdot 0 \pm 0 \cdot 1°C$ in solutions containing $0 \cdot 001$M Zn^{++}, $0 \cdot 0005$M HNO_3, and $KNO_3 - (CH_2COOK)_2$ mixtures in proportions so as to keep the ionic strength of the medium at

0·6M while the concentration of the succinate ion was changed from 0·02 to 0·20M. Analysis of the data by Hume-DeFord method of mathematical treatment showed the existence of three complexes, Zn (Succ), K_2Zn (Succ)$_2$ and K_4Zn (Succ)$_3$ with formation constant values 26, 15 and 1700 respectively. Effect of change of ionic media and metal ion concentration on the stability of the complexes was also studied.

48. Polarographic Studies of Metal Complexes, Part V. The System: $ZnSO_4$—Pot. Salicylate—KNO_3—H_2O

A. C. Chatterji *and* J. Prashad, *Chemical Laboratories, Lucknow University, Lucknow*

The $E_{\frac{1}{2}}$ and i_d of Zn^{++} were determined under N_2 atmosphere each time at 35 0 ± 0·1°C in solutions containing 0·001M Zn^{++}, 0 0005M HNO_3, and pot. nitrate-salicylate mixtures in proportions so as to keep the ionic strength of the medium at 1·1M. Analysis of the data by Hume-DeFord method of mathematical treatment revealed the existence of two complexes, Zn (Sal) and Zn (Sal)$_2^{--}$ with formation constant values 18 and 600 respectively. Effect of change of pH, metal ion concentration and ionic medium on the stability of the complexes has also been studied.

49. Adsorption of Congo Red on Hydrous Chromium Oxide

Rajesh Behari Hajela *and* Satyeshwar Ghosh, *Chemical Laboratories, University of Allahabad, Allahabad*

Hydrous chromium oxide has been found to be a good absorbent for an acid dye as Congo Red. The adsorptive capacities of hydrous chromium oxide for acid and basic dyes and also the effect of temperature on the adsorption of Congo Red have been discussed.

Heat of adsorption has been calculated by the equation :

$$\frac{RT_1T_2}{T_1-T_2} \; \log \; \frac{C_1}{C_2} = Q$$

where C_1 and C_2 are the end concentrations for the same amount of dye adsorbed at absolute temperatures T_1 and T_2. It is concluded that :

1. The adsorption of Congo Red by hydrous oxide is an exothermal process.

2. The heat of adsorption values are low, and increases with increasing coverage then passes from a maxima showing that the surface is heterogeneous. It further suggests that the adsorption of Congo Red by hydrous chromium oxide is a chemisorption process.

3. It has been further noticed that the mode of preparation changes the character of the hydrous oxide as a basic or an acidic mordant.

3

50. Studies on the Complexes of Sodium Polymetaphosphate Glass : Use of Solubility Data for Calculating Thermodynamic Constants of Soluble Barium and Lead Complexes

A. C. Chatterji *and* R. M. Bhatnagar, *Chemical Laboratories, Lucknow University, Lucknow*

Following expression for determining co-ordination number and formation constant, assuming $NaPO_3$ as independent unit in complex formation, has been derived by using law of mass action.

$$K = \frac{4a}{K_{sp} - (n+2)\,a^n}$$

where K = formation constant

K_s = Solubility product of metal metaphosphate

a = Conc. of metal ion in the complex

n = Co-ordination number

p = Conc. of poly-phosphate solution added.

Knowing $\log_{10}K$ at two different temperatures, other thermodynamic constants given in the table below were calculated according to standard equations.

Metal	n	$\log_{10} K$ at 35°C	$\log_{10} K$ at 45°C	$\triangle F$ Kcal	$\triangle S$ cal	$\triangle H$ Kcal
Pb++	1	10·38	10·22	−15·39	−11	−18·28
Ba++	1	10·32	10·07	−14·55	−11	−17·0

51. Studies on Periodic Formation : Time and Distance Relationship of Silver Chromate Precipitation in Presence of Various Electrolytes

A. C. Chatterji *and* R. M. Bhatnagar, *Chemistry Department, Lucknow University, Lucknow*

The phenomenon of Liesegang ring formation was studied microscopically, by diffusing silver nitrate in agar agar media, impregnated with potassium chromate in presence of electrolytes *i.e.* pot. nitrate, amonium nitrate, sodium acetate and thorium nitrate). Morse's equation was used to calculate time coefficient, space coefficient, and the ratio $X/\sqrt{T}$ in each set of observation.

Electrolyte	Conc.	Time Coefficient	Space Coeff	$\dfrac{X+a}{\sqrt{T}}$
Pot. nitrate	5%	1·31	1·18	0·0107
Sod. acetate	1%	1·17	1·08	0·0099
Thorium nitrate	0·0002 N	1·13	1·14	0·0061
Thorium nitrate	0·0001 N	1·09	1·08	0·0089

It has been observed that the presence of these electrolytes increases the sharpness of the rings. Fine and quick formation of rings was also observed with thorium nitrate. Morse equation was also verified when a straight line was obtained by plotting X against $\sqrt{T}$.

52. Conductometric Studies on Dissociation of Murexide : Influence of Temperature

R. K. Chaturvedi, *Department of Physical Chemistry, H. B. Technological Institute Kanpur*

Conductance measurements of aqueous solutions of murexide (ammonium purpurate) have been carried out at 25°C and 30°C. The variation of the equivalent conductance with square root of concentration is linear. The slope of this plot indicates the existence of associated ion pairs in the system. The data have been analysed by the modified form of Davies method applicable to such systems. From this modified method the second approximations of the degree of dissociation corresponding to different concentrations of murexide have been computed. From these the values of the classical (k) and thermodynamic dissociation constants (K) of murexide have been computed. pK values are $1 \cdot 56 \pm 0 \cdot 03$ and $1 \cdot 77 \pm 0 \cdot 04$ at 25°C and 30°C respectively. From these data the values of the thermodynamic functions such as $\triangle F$, $\triangle H$, $\triangle S$ have been computed, These have the following values at temperatures (in °A) denoted by postscripts :

$$\triangle F_{298} = 2 \cdot 414 \text{ K. Cals Mole}^{-1} ; \quad \triangle F_{303} = 2 \cdot 163 \text{ K. Cals. Mole}^{-1}$$

$$\triangle H_{300 \cdot 5} = 17 \cdot 355 \text{ K. Cals. Mole}^{-1} ; \quad \triangle S_{300 \cdot 5} = 50 \cdot 14 \text{ Cals deg}^{-1} \text{ Mole}^{-1}$$

53. On Mutual Relationships Between Various Integral Transforms

C. B. L. Varma, *Mathematics Department, T. R. S. College, Rewa*

In this paper the relationships existing between various Integral Transforms have been investigated. Besides the relationship between the Laplace Transform and its generalisations, those existing between the generalisations themselves have also been obtained. The interrelationship between the Hankel and K-Transform, and between K- and H- Transforms has also been dealt with.

54. Relations Between Hankel and Generalised Laplace Transforms

C. B. L. Varma, *Mathematics Department, T. R. S. College, Rewa*

Meijer and R. S. Varma have given the generalisations of the well known Laplace Transform

$$\text{L } \{f ; p\} = \int_{0}^{\infty} e^{-pt} f(t) \, dt, \text{ R } (p) > 0$$

in the forms

$$k_{\lambda} \{f ; p\} = \int_{0}^{\infty} (pt)^{\frac{1}{2}} \text{ K}_{\lambda} (pt) f(t) \, dt$$

and

$$V_{k_1 m}\ \{f, p\} = \int_0^\infty e^{-\frac{1}{2} pt} (pt)^{m-\frac{1}{2}}\ W_{k_1 m}\ (pt)\, f\ (t)\ dt. \qquad R\ (p) > 0$$

respectively, while the Hankel Transform of order ν is defined by the equation

$$H_\nu\ \{f; \zeta\} = \int_0^\infty t\, J_\nu\ (\zeta t)\, f\ (t)\ dt, \qquad R\ (\zeta) > 0$$

In this paper the author has obtained two theorems establishing the relationship between H_p and k_λ, and H_ν and $V_{k_1 m}$ and has utilized them to evaluate certain integrals involving G-function.

55. Complexes of Adenosine, Adenine, Creatine and Amino-acid with Phosphoric and other Acids

N. R. Dhar *and* Guru Prasanna Ghosh, *Chemical Laboratories, Sheila Dhar Institute of Soil Science, University of Allahabad*

Remarkably stable complexes are formed when adenosine and adenine are added to phosphoric acid. Stable complexes are also formed when creatine and amino acids are added to phosphoric and other acids.

56. Influence of Phosphates and Light on Induced Oxidation of Sodium Nitrite

N. R. Dhar *and* R. N. Tewari, *Chemical Laboratories, Sheila Dhar Institute of Soil Science, University of Allahabad*

Studies of induced oxidation of sodium nitrite solution using ferrous hydroxide as inducer, in presence of phosphates and light have shown that the oxidation of sodium nitrite is always greater in light than in the dark.

The di and tribasic phosphates and Tata basic slag enhance the oxidation whereas mono basic phosphates decrease the oxidation.

57. Studies in Silicate Gels

N. R. Dhar *and* R. G. Chatterji, *Chemical Laboratories, Sheila Dhar Institute of Soil Science, University of Allahabad*

Gels of the silicates of aluminium, chromium, iron, calcium, strontium, barium, copper, nickel, cobalt, manganese, zinc and magnesium have been prepared by mixing equivalent proportions of sodium silicate and suitable salt solutions.

The conditions under which stable gels are formed have been investigated.

The dehydration of the gels of the silicates of iron, aluminium, chromium, calcium, strontium and barium has been studied.

It has been found that the most of the water in these gels is mechanically immobilised in the mesh work of the solid phase as the water is readily released on keeping the gels in dry air. It seems some portion of the water is bound more tenaciously as it is very difficult to dehydrate the gel completely.

These gels are transformed into xerogels by drying and they can no longer swell considerably and are converted to hard structures of fantastic shapes.

SECTION OF BIOLOGICAL SCIENCES

ABSTRACTS OF PAPERS

1. Pedo-Ecological Zones and Soil-Types in the Sutlej-Tons Himalayan Region

S. D. Kaushic, *Department of Geograpy, Hapur*

Edaphic Ecology :

Soil is a composite living organism, which evolves in an ecological milieu. There is an unbreakable and continuous functional inter-relationship between soil and its surrounding environment. The functional interaction brings about changes not only in the composition and properties of soil, but also in the dynamics of the physical, chemical, and biological processes of soil-morphology. In every stage of pedomorphosis, every pedo-ecological region or locality maintains a triadic balance between soil, function, and environment—both natural and cultural. Thus, soil is the end-product of physical, chemical, biological and cultural factors which act and react together in pedo-genetic processes. It develops in space, through differential temporal stages, under the action of pedo-agencies, in an ecological setting. The edaphic-ecology is a five-aspected complex discipline.

The chief features of edaphic ecology of the Sutlej-Tons Himalayan region are given in the paper.

Geographical Environment :

Location—The Sutlej-Tons Himalayan region comprises the eastern part of Himanchal Pradesh, lying between 30°45'—32°10' N lats. and 77°2'—78°55' E longitudes.

Topography and its effects on the soils of the region—It is on the river-terraces, alluvial fans, and concave slopes that the most fertile soils of the region have developed.

Climate—The effects of climate and micro-climate on the soils of the region are given. There are 7 *Altitudinal-Climato-Vegetative Zones which coincide with the Pedo-Ecological Zones of this region* :

(1) Soni-Kumarsain Sutlej valley bottom zone : Temperature and rainfall figs.

(2) Sutlej Valley higher zone (3500-6000 ft). June 21-26 C. Jan. 7-10 C. etc.

(3) Pabar-Shalvi-Tons Basin (4000-7000 ft). Temp. 21-25; 6-9; R. 40-60 inches.

(4) Upper Giri Basin (4250-7250 ft) : Temp. C. 20-24; 5-8; R. F. 35-40 inches.

(5) Sutlej-Tons Divide (7000-10,000 ft) : C. 15-20 ; 1-5 ; R. F. 50-60 inches.

(6) Rampur-Bushahr Sub-region (3000-6500 ft) : C. 20-27; 6-11 ; R. F. 12-35 inches.

(7) Lower Kinnaur (6000-8000) Temp. C. 18-21 ; 3-7 ; R. F. 30-35.

(8) Upper Kinnaur (Chini Valley) (8000-10,000): C. 16-18 ; 1-3 ; R. 15-20 (Mediter. Type).

(9) Upper Kinnaur Alpine Zone (10,000-13,500) C. 6-16;-6 to 0; 6-12 (GlacialType)

Differing Soils—Even on the same slope, in the same locality, there are different types of soils : (1) Lithosols in glacial region ; (2) Podzols under coniferous forests ; (3) 'Karali' soils on unterraced fields ; 'Bakhal' brown-earth soils under cultivation in one-crop zone; 'Barani' soils in two-crop zone, etc. Soils show close affinity to the parent material due to heavy erosion. Immature and acidic soils.

Soil-sample survey—conducted on simple random sampling basis and also on stratified random sampling basis.

Results of mechanical and chemical analyses :

Ecological zone	Sample Colour	Texture	pH	CaO%	N	P$_2$O$_5$	K$_2$O
Soni-Kumarsain :	1 Dark-brown	Loam ...	6·50	1·78	0·20	0·08	0·55
	2 Grey-brown	Cleyey loam	7·50	3·85	0·25	0·30	0·60
	10 Yellowish Brown	Loam ...	6·35	1·96	0·36	0·25	0·28
Middle Kinnaur	76 Grey-brown	Sandy loam	6·4	0·43	0·35	0·15	2·12
Upper Kinnaur	89 Pale-brown	Sandy loam	6·0	0·40	0·22	0·29	0·78

Potato soils and Fruit-soils—Results show that the soils of this zone are, though poor in fertility for food-grain crops, yet very suitable for potato, apples, apricots, walnuts, neoza, pista, almonds and grapes including raisin grapes.

2. An Experimental study of thanatosis in *Carausius morosus*

S. C. Saxena, *Department of Zoology, University of Gorakhpur, Gorakhpur*

Besides several others, pressing the sides of the thorax by thumb and fore finger has been proved to be an easiest method of inducing thanatosis in *C. morosus*. While in this state the insect assumes an immobile posture with the antennae stretched forward and tightly folded to the head. The position of the legs vary in individuals. The termination of thanatosis begins with the movement of antennae followed by the movement of the legs.

Different periods of thanatosis were recorded at different ages. But at a certain age the normal value is reached.

On continous application of the stimulus the insect reaches a fatigue stage when it no more responds in the normal way.

Decapitated insects failed to show thanatosis whereas it was possible to induce thanatosis in the insects whose abdomen were cut. No effect on thanatosis was recorded on cutting the legs and antennae.

C. morosus responds in a different fashion to the illuminations. Thanatosis state is prolonged on keeping them under the light of different intensities. Ultra violet light had a similar effect. Soon after switching the light off the termination of thanatosis was noticed.

3. Influence of Sulpha-drugs on Germination, Growth, Yield and Quality of Early paddy (*Oryza sativa; Var. Kuari*) and Tomato (*Lycopersicum esculentum; Var. Ponderosa*)

K. Kumar *and* O. S. Singh, *College of Agriculture, Benares Hindu University, Varanasi*

The effect of five sulpha-drugs, namely, sulphadiazine, sulphathiozol, sulpha-guanidine, sulphanilamide and MB 693 at 10 and 50 p.p.m. concentrations, on early paddy and tomato plants, was studied under sand culture conditions.

Maximum germination percentage and early root and shoot growth of early paddy, were brought about by 10 p.p.m. concentration of sulphathiozol followed by sulphadiazine 10, and 50 p.p.m. and sulphathiozol 50 p.p.m. concentrations. In tomato the maximum germination percentage was achieved not only in sulpha-thiozol but also in MB 693 at 10 p.p.m. treatment.

Sulphaguanidine 50 p.p.m. was found to be the most responsive dose in increasing the vegetative characters of paddy plants, sulphadiozine and sulpha-thiozol 10 p.p.m. also showed a promising result over control. Sulphanilamide at its 50 p.p.m. concentration proved to be as the growth inhibitor in paddy and tomato both. Cholosis, more or less, was marked in both type of plants with all the treatments.

A number of positive physical and chemical characters of grains of early paddy, were significantly influenced by sulphaguanidine at 50 p.p.m. concentration which was followed by sulphaguanidine 10 p.p.m. and sulphadizine 50 p.p m. 10 p.p.m. sulphaguanidine was found to be most superior in influencing the physical characters, vitamin C and carbohydrates content in tomato fruits. Its 50 p.p.n. concentration behaved less effectively than the lower concentration tried.

4. Studies on the Morphology, Intraspecific Variations, Egg and Larva of *Aspidogaster indicum* Dayal, 1943 (Trematoda : *Aspidogastrea*)

S. L. Rai, *Department of Zoology, Mahakoshal Mahavidyalaya, Jabalpur,* M.P.

The study of morphological and intraspecific variations is based on 563 parasites recovered from the stomach of six specimens of the fish *Barbus tor* (Ham.) caught from the river Hiran, 24 miles from Jabalpur. These parasites have been grouped into six samples. *Variations have been studied in the parasites of each sample separately.* The ventral adesive disc or haptor is divided by three longitudinal and fourteen cross ridges in 54 acetabula, arranged in four longitudinal rows. Interest-ing variations are recorded in the shape and lobation of testis, from ovoid, spherical, trangular and smooth to nearly 4 lobed condition. The size of the testis varies from less than the size of the ovary to nearly 5 times bigger. The cirrus sac in general is pear shaped. However, it is smaller in size in those specimens which

have larger testis and the ratio of testis and ovary is nearly 5 : 1. In specimens which have testis and ovary nearly equal in size, the cirrus sac is comparatively large. These variations are periodic.

Eggs oval, operculate and embryonated. They hatch in tap water of 7.1 — 7.45 ph. within 5—8 days at 20—22·5°c temp. The larva, when emerges from the egg, has a well developed oral sucker, pharynx, a small intestine and a well developed acetabula without alveoli. The further stages of development are in progress.

5. On a New Species of the Genus Neoacanthoparyphium Yamaguti, 1958 (Trematoda : *Echinostomatidae*)

S. L. Rai, *Department of Zoology, Mahakoshal Mahavidyalaya, Jabalpur, M.P.*

Number of parasites of *Neoacanthoparyphium indicum* n. sp. were recovered from the intestine of *Neophron percnopterus* (Linnaeus) shot from Bal Sagar locality, 6 miles away from Jabalpur. The cuticle is spiny from the anterior end of the body up to the anterior level of the ovary. The collar is well developed, with double dorsally uninterrupted crown of 38 spines; and group of four spines, end spines comparatively larger than the rest. Oral sucker moderately developed. Prepharynx and pharynx present; oesophagus long. Acetabulum large. Testes tandem. Cirrus sac oval, contains unipartite vesicula seminis, parsprostatica and long cirrus Ovary oval, median to submedian. Receptaculum seminis present. Vitelline follicles extend from the anterior level of anterior testis to the posterior end of the body, may or may not be confluent in the post-testicular region. Vitelline reservoir well developed. Eggs oval.

6. Effect of grazing on the general herbags of Banaras Hindu University grounds and a study of seed character and reproductive capacity of four weeds

H. R. Sant, *Varanasi*

Effect of grazing on the general herbage and a study of seed character and reproductive capacity of four weeds viz. (1) *Evolvulus alsinoides*, (2) *Evolvulus nummularius*, (3) *Indigofera linifolia*, and (4) *Convolvulus pluricaulis*, have been studied and these show distinctive distribution in protected, medium and overgrazed fields of Banaras Hindu University campus. The effect of grazing on general herbage show that many plant species viz., *Alysicarpus monilifer*, *Boerhavia diffusa*, *Evolvulus alsinoides*, *Evolvulus nummularius* etc. show progression in their populations as a result of hevy grazing, while *Indigofera linifolia*, *Desmodium triflorum*, *Dischanthium annulatum* etc., declines. *Convolvulus pluricaulis* does not respond to grazing (i.e. it is neutral).

The biological equipment of four herbs viz. *Evolvulus alsinoides*, *Evolvulus nummularius*, *Indigofera linifolia* and *Convolvulus pluricaulis* versus grazing in terms of seed output and reproductive capacity have been estimated.

7. Habit, habitat, and distribution features of some common plants in Rajasthan

G. S. Puri *and* S. K. Jain, *Central Botanical Laboratory, Allahabad*

The State of Rajasthan in North-Western India has a very interesting flora. It it the meeting ground for the Xerophytic element of Africa and Arabia and the Mesophytic flora of Indo-Malayan element.

The flora west of the Aravallis as now known comprises of about 660 species, belonging to 368 genera and 89 natural orders. The dominant ten families are Gramineae, Papilionaceae, Compositae, Cyperaceae, Acanthaceae, Euphorbiaceae, Convolvulaceae, Malvaceae, Boraginaceae and Cucurbitaceae.

There is paucity of tree vegetation. The ten dominant families include 365 species of which only 7 are tree species.

There is very little endemic flora. A comparison of the occurance of more common 52 species with adjacent areas such as Bombay, Saurashtra, Kutch, Indus delta, Sind and Punjab shows close resemblance in their floras. More than half of these 52 species are common to all the six regions, whereas only one or two species are exclusive to Rajasthan. The area is being constantly invaded by the flora of adjacent regions.

The flora has close relationship with the soil and rock sub-stratum. Depending upon the habitat type distinct plant communities are found.

The studies suggest trends in succession of the flora and provide useful indications for soil conservation and afforestation work.

8. Comparative study of the Functional Anatomy of the Respiratory Organs of Water-Breathing *Labeo rohita* and Air-Breathing *Ophicephalus striatus*

Devendra B. Saxena, *Department of Zoology, D. A. V. College, Kanpur*

Fish ordinarily makes use of the oxygen contained in the air dissolved in water by means of gills. The habit of fresh-water fish of the tropic to supplement the respiration of gills by aerial respiration, provides an example of a fundamental change in the functioning of one of the main physiological systems of the body. It is of special interest from this point of view because it is a change which must have occurred very frequently and in many different ways. It is also a change which must have occurred in the sequence of adaptations which made possible the migration of fish from water to land,

The aerial respiration in tropical fresh-water fish provides an example of a fundamental change in the functioning of one of the main systems of the body with resultant modifications of the associated structures. The gill-lamellae (in *L. rohita*—32 & *O. striatus*—15) and the total respiratory area (in *L. rohita*—varies from 55640 to 100600 sq. mm. & *O. striatus*—from 10860 to 26510 sq. mm.) of the fishes differ markedly; and in the fishes with accessary respiratory organs these show reduction in number and size, as in *O. striatus* the gill filaments are borne on both the hemibranches of the first three gill-arches while on the fourth gill-arch the posterior hemibranch is represented by degenerate and reduced filaments which are few in number.

In *L. rohita* the gill rakers form sieve-like apparatus in the gill clefts which prevents food particles and debris from passing out from the phaynx into the branchial chamber. In *O. striatus* the gill clefts are kept open and filaments spaced by denticuliform gill-rakers arranged in the rows.

The accessary respiratory organs in *O. striatus* consist of a pair of a large suprabranchial chamber. The hyomandibular process and the labyrinthine plate

of the first epibranchial provides extra surface for the folds of the flattened epithelium, below which is a rich network of capillaries which are brought close to the contained air by thinning of the epithelial cells above them.

The circulatory system which is intimately connected with the respiratory organs show marked modifications along with the elaboration of the respiratory mechanism. The blood to the respiratory organs is supplied by the first and the second afferent and efferent arteries and is returned to the heart after aeration in the accessory respiratory organs through the suprabranchial veins. So the blood collected by the third and fourth efferent only is sent for circulation to the body and it is the mixed blood which is sent from the heart to the gills for further aeration.

9. On a new species of *Anabaenopsis*

D. C. Pandey *and* A. K. Mitra, *Botany Department, University of Allahabad, Allahabad*

An interesting blue-green alga, which appeared as scattered bright blue-green patches on moist cultures of the paddy field soils of Ghazipur district (Uttar Pradesh), has been studied in unialgal culture on various media.

The filaments are usually straight and are rarely bent as in other species of the genus. In the young condition the filaments are enclosed in a very fine delicate and transparent sheath but later the individual sheaths become diffluent resulting in a common membranous sheet in which a number of trichomes, usually running in a parallel fashion, remain embedded. This character also is not present in other known members of the genus.

Usually the filaments are $50 - 150\ \mu$ in length and the trichome measures $2\ \mu - (2 \cdot 5 - 3 \cdot 5\ \mu) - 4\ \mu$ in diameter. The cells are barrel-shaped, deeply constricted and the length varies from $2 - 7\ \mu$. On solid medium, the contents are homogeneous but pseudo-vacuoles are prominent in the liquid medium. Each filament usually possesses two terminal heterocysts, one at each end as is characteristic of the genus. Two adjacent cells somewhere in the middle of a filament develop into two new terminal heterocysts and the filament breaks between these to form two new filaments. A heterocyst may be globose, sub-spherical or conical. The diameter ranges from $3 - 4 \cdot 5\ \mu\ (- 5\ \mu)$ and the length $3 - 5\ \mu$. Usually ellipsoidal or ovate-oblong akinetes develop in the middle away from a heterocyst. Their number varies from $1 - 5$. But in rare cases an entire trichome converts itself into a chain of akinetes which is a new feature. The diameter of a mature akinete ranges between $(5)6 - 7 \cdot 5\ \mu$ in breadth and the length from $(6)7 \cdot 5 - 9\ \mu$.

On the basis of the characters described above the alga has been identified to be a new species of *Anabaenopsis* and has been named *A. ambigua* n. sp.

On comparison with the species so far described it is found to come closest to *A. tanganyikae* (West) Wolosz. *et* Miller to which it resembles to a certain extent in diameter of the cells, heterocysts and akinetes but not in their length which is shorter. But this form stands unique in its terrestrial habit, in the possession of usually straight filaments, in the formation of a common gelatinous matrix, in the presence of deeply constricted barrel-shaped cells and in the production of a long chain of akinetes. It is, therefore, presented as a new species *A. ambigua* n. sp. In many of these characters it resembles *Anabaena* although retains the characteristic features of *Anabaenopsis*.

10. A functional study of the Pituitary of the freshwater Teleost *Labeo rohita* (Ham).

H. A. Khan, *Department of Zoology, Lucknow University, Lucknow*

An historical account of the study of Teleost pituitary has been given. The morphology and cytology of the pituitary has been described by selective staining techniques. Various fluids *e.g.* Bouin's fluid, Formol-Sublimate and Dawson and Friedgood fluid, have been used for fixing the glands. The following methods were used for staining pituitary of *Labeo rohita* :

1. Heidenhain's Azan method.

2. Masson's Trichrome.

3. Periodic Acid Schiff's stain.

4. Aldehyde Fuchsin with Orange G and light green.

5. Combined Aldehyde-Fuchin and Schiff's stain.

6. Combined Aldehyde-Thionin and Schiff's stain.

The pituitary is an ovoid body situated ventral to the brain attached to the infundibulum by a short pituitary stalk. The pituitary is divisible into neurohypophysis and adenohypophysis. The neurohypophysis sends out small branches into pro-adenohypophysis and meso-adenohypophysis, the main trunk of this process continues into meta-adenohypophysis and there it arborizes. The neurohypophysis is composed of loosely arranged fibres, among which often droplets, irregular patches of colloid material and a few glandular cells are present. The blood vessels and the cell types acidophils, basophils and chromophobes are present in various parts of the adenohypophysis.

11. A Functional study of the Pituitary of the fresh water Teleost *Rita rita* (Ham.)

H. A. Khan, *Zoology Department, Lucknow University, Lucknow*

The morphology and cytology of the pituitary gland has been described by the selective staining technique. The different fixatives used were Bouin's fluid, Formol-Sublimate and Dawson and Friedgood fluid. The following were the methods used for staining pituitary of *Rita rita.*

1. Heidenhain's Azan method.

2. Masson's Trichrome.

3. Periodic Acid Schiff's stain.

4. Aldehyde-Fuchsin with Orange G and light green.

The pituitary is a conical organ situated ventral to the brain attached to it by an indistinct stalk. It lies in a slight hollow in the cranial floor. The pituitary consists of Neurohypophysis and Adenohypophysis. The neurohypophysis is composed of loosely arranged fibres among which neuroglia cells and irregular patches of colloid material are present. Ocassionally a few glandular cells are also seen. The adenohypophysis is divided into pro-adenohypophysis, meso-adenohypophysis and meta-adenohypophysis. The histological features, blood supply, relative size and diagnostic characters of cells present in various parts of the adenohypophysis have been described for the first time.

12. Fungi causing plant diseases at Jabalpur (Madhya Pradesh)—V

G. P. Agarwal *and* S. K. Hasija, *Botany Department, Mahakoshal Mahavidyalaya, Jabalpur*

Agarwal, Nema and Beliram (1959), Agarwal and Beliram (1960), Agarwal (1960) and Nema and Agarwal (1960) have described in the first four series of the paper one hundred and seven parasitic fungi occurring at Jabalpur. Twelve more deuteromycetes, which include 4 new species, one new fungus record for the country, 2 new host records and the rest new records for the state, are being described in this paper. *Pyrenochaeta tandonii* Agarwal & Hasija on *Anogeissus latifolia, Pestalotiopsis terminalae* Agarwal & Hasija on *Terminalia bellerica* and *Pestalotiopsis woodfordiae* Agarwal & Hasija on *Woodfordia fructicosa* are the four new species. *Pestalotiopsis japonica* (Syd.) Steyaert on *Ficus glomerata* is a new fungus record for the country. *Cassia tora* for *Periconia byssoides* Pers. ex Schw. and *Erythrina indica* for *Helminthosporium erythrinae* Thirum. & Naras. are new host records. *Phyllosticta ipomoea* Ell. & Kellerm on *Ipomoea* sp., *P. sesbaniae* Syd. on *Sesbania grandiflora, Phleospora cassiae* Thirum. & Naras. on *Cassia fistula, Alternaria citri* Pierce on *Citrus limonia* and *Cercoseptoria balsaminae* Syd. on *Impatiens balsamina* are new records for the state.

13. Fungi causing plant diseases at Jabalpur (Madhya Pradesh)—VI. Some *Cercosporae*

G. P. Agarwal *and* S. K. Hasija, *Botany Department, Mahakoshal Mahavidyalaya, Jabalpur, M. P.*

In the first five parts of the paper 119 fungi causing plant diseases at Jabalpur and its suburbs have been reported. These include 13 *Cercosporae*. The present paper describes 8 more *Cercosporae* causing leaf spots. It includes *Cercospora elaeodendri* Agarwal & Hasija on *Elaeodendron glaucum* Pers., *C. agarwalii* Chupp on *Vitex negundo*. L., the two new species, *C. justiciicola* Tai on *Justicia simplex, C. hyalospora* Muller & Chupp on *Sida cordifolia* L., *C. sonchi* Chupp on *Sonchus arvensis* L., four new fungus records for India. *Lagerstroemia parviflora* Roxb. is reported to be a new host for *C. paramignyae* Thirum. & Chupp. *C. Neriell* Sacc. on leaves of *Nerium oleander* L., is a new record for the state.

14. Trial with different insecticides on the control of *plusia orichalcea* caterpillars (*Noctuidae* : Lepidoptera) on lobia crop

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Tests were made with four different insecticides, 5% BHC dust, 0.125% Endrin emulsion, 0.25% DDT emulsion and 0.25% BHC+DDT wettable powder, with a view to find out their relative efficacy against the semi-looper caterpillars of *Plusia orichalcea* (commonly known as 'Semi-looper caterpillars of Pea') on Lobia (*Vigna* sp.) crop. The experiment was performed in a farmer's field at Allahabad in a non-replicated manner in five equal sized plots, each one measuring 60×180 sq. feet. 0.125% Endrin emulsion spray and 0.25% DDT emulsion spray gave nearly 100% control whereas 5% BHC dust and 0.25% BHC+DDT wettable powder gave 91.461% and 93.342% mortality respectively. The working cost per acre of each insecticide used was Rs. 3.00 for 5% BHC dust, Rs. 18.80 for 0.125% Endrin emulsion, Rs. 8.80 for 0.25% DDT emulsion and Rs. 1.64 for 0.25% BHC+DDT wettable powder.

It has, therefore, been found out that 0.25% BHC+DDT wettable powder was cheapest amongst all the insecticides used and it also gave better control than

5% BHC dust which has been in extensive use so far against this pest. 0·125% Endrin emulsion and 0·25% DDT emulsion are economically impracticable because their cost per acre is very high.

The results of this experiment has been based on 45 sq. feet area examined per plot and the corrected mortality has been calculated using the following formula: —

$$\text{Corrected mortality} = \frac{(\text{Mortality in treatment} - \text{Mortality in control} \times 100}{100 - \text{Mortality in control}}$$

15. On the Life-history and mode of perennation of *Myxosarcina spectabilis* Geitler and Ruttner var. *decolorata.* n. var.

A. K. Varma *and* A. K. Mitra, *Botany Department, University of Allahabad, Allahabad*

The genus *Myxosarcina* was established by Printz in 1921, and since then about five species have been described but in none of them has any study of the complete life-history or mode of perennation been made. Geitler (1942) is also of the opinion that *Myxosarcina* has not been studied enough and refers to some of the species and forms as growth stages of others.

The thallus of the present *Myxosarcina* is made up of a mass of colonies and ranges from 70—300μ in diameter. The individual colonies are compact, containing a large number of cells and are covered by a 1—2 μ thick, elastic, hyaline and unstratified envelope. In old cultures the colony usually becomes irregular in outline due to development of projecting cells of daughter colonies all over the surface. Cell division in young colonies is very regular cutting off cells in three planes at right angles to one another. The cells are invariably arranged in transverse and vertical rows. In old and mature condition division becomes irregular so that arrangement in rows become more or less obscured, and the cells due to mutual pressure may appear to be polygonal. The cells vary from 5 to 8 μ in diameter which sometimes may diminish to $\pm$ 3 μ in diameter due to frequent division.

Reproduction takes place by formation of 1—4 endospores per cell which are naked, round to globose 3—5 μ in diameter of light blue green colour and are liberated by rupture of the parent wall as well as of the colonial envelope both of which remains visible after their liberation as an empty net-work. The naked endospores subsequently assume a globular shape and secretes an envelope around itself. The first division is followed by one of the cell dividing by a wall at right angles to the first and this results in a 'T' shaped body that forms a quadrant. Ultimately division in three planes results in a three dimensional colony.

The alga perennates both in the natural and cultural condition by the colonial envelope turning pale yellow, or yellow and the individual sheath also becomes thick. The cell contents turn yellowish and sometimes acquire granulations. On putting such a colony on fresh medium, the contents soon turn deep blue-green and are liberated in a naked condition like that of endospores and the stages of development shown by endospores are all repeated. This variety differs from the species chiefly in the absence of any violet colour of the cells.

16. On a new avian cestode belonging to the subfamily *hymenolepidinae* perrier, 1897 from Delhi state

L. N. Johri, *Department of Zoology, University of Delhi, Delhi*

Hymenolepis longiovata n. sp.

Host: Eroplia minuta minuta

Maximum length 133 and the greatest breadth 1·38 (mature segments) and 2·5 (gravid segments). The genital pores unilateral. Scolex 0·209 long and 0·18 in maximum diameter. Suckers 0·10—0·116 in diameter. Acetabular hooks present. Rostellum 0·04 in diameter. Ten rostellar hooks each measuring 0·061 in length. Rostellar sac (0·20 ×0 085) occupying the entire length of the scolex. Testes three, sub-equal and arranged in a transverse row. Cirrus sac measures 0·09 ×0·120 ×0·045 (mature segments) and 0·194—0·20 (gravid segments). Genital cloaca very well developed, measuring 0·09—0·10 × 0·065—0·8. Ovary transversely elongated in the width of the segment and is in close contact with all the testes. Vitelline gland measures 0 07—0·1 in diameter. Uterus irregularly lobed sac almost filling the entire segment. Eggs and onchospheres measure 0·022—0·024 and 0·01—0·013 in diameter respectively.

The present form has been compared with the allied species of the genus *Hymenolepis* Weinland 1858. The possession of the acetabular hooks, enormously enlarged genital cloaca, the relative and the absolute size of the cirrus sac and the characteristic disposition of the ovary in the present form clearly distinguish it from all of them. A new species *H. longiovata* n. sp., is, threfore, created for its reception.

17. Report on a new anoplocephalid cestode from Delhi state

L. N. Johri, *Department of Zoology, University of Delhi*

Killigrewia indica n. sp.

Host: Cloropis auriforns (Temm. & Laug)

Maximum length 100·5. Greatest breadth 4·65 (Mature segments) and 6 0 (gravid segments). All segments much broader than long. Genital pores irregularly alternate and located at one-third of the margin. Scolex 0·64 in maximum diameter. Suckers 0·6—0·7 in diameter. Testes 91—100 arranged in two lateral groups: poral and aporal groups constitute 37—41 & 54—59 respectively. Cirrus sac measuring 0·32 ×0·04 (mature segments) and 0·58 ×0·08 (gravid segments) and reaches ventral longitudinal excretory vessel. Cirrus simple without any armature. Ovary slightly poral and is provided with numerous lobulations from its lateral borders. Vitelline gland with small lobulations measuring 0·43 in diameter. Shell gland measures 0·25 in diameter. Uterus with numerous backward and forward 25—30 diverticulae from the main uterine stem. Eggs measure 0·015—0·018 in diameter.

The present form represents outstanding characters on account of absolute and relative size of cirrus sac, large number of testes, presence of a distinct receptaculum seminis and smaller eggs. It has been compared with the allied forms and is separated out as a distinct and new species.

18. Soil Erosion in Kashmir Himalayas

J. S. Singh *and* M. K. Wali, *Central Botanical Laboratory, Allahabad*

A special survey was conducted by the authors to investigate the problems of soil erosion in Kashmir Himalayas which have received very scanty attention in the past. The places visited were : Tangmarg, Gulmarg, Khilanmarg embracing the Ningal Nullah zone and Baramulla district in South Kashmir, Banihal, Quazigund and Shopian in North Kashmir and Kud, Batote, Ramban valley in the Jammu province. In Kashmir particularly the Southern zone, both gully erosion and sheet erosion were seen and in Jammu and Northern Kashmir sheet erosion seemed to be dominating. The usual factors like the disturbance of the original vegetation cover by biotic interference like the cutting of felling of trees, excessive grazing, burning of vegetation seem to be at work here also. Moreover in pure coniferous forests, since there is no proper conservation of water the chances of soil erosion and land slips are definitely more. All these factors are discussed in detail in the paper.

To combat the problem of erosion, afforestation of the affected areas seems to be the most effective. To cite an example, Shankrachrya hills (Srinagar) in the very recent past showed a great degree of erosion. Later afforestation of coniferous species viz. *Pinus wallichiana, P. roxburghii, P. sylvestris, P. canariensis, P. hilapinensis, Cupressus arizonica, C. sempervirens, Juniperus* sp., *Cedrus deodara* and broad leaved species like *Juglans regia, Aesculas indica, Fraxinous excelsior* was done and the result is that there has been no erosion now at this place covered by the above named species. Thus afforestation can greatly help us out of the problems created by erosion. As far as excessive grazing is concerned a policy of restricted and rotational grazing can be applied with success.

The details are enumerated in the paper besides about twenty photographs.

19. Effect of applications of nitrogen and phosphorus on the rate of respiration of *Brassica alba (var.* T) plants with respect to their sugar and fat content

A. Singh *and* J. S. Singh, *Central Botanical Laboratory, Allahabad*

A study of respiration and sugar and fat content of *Brassica alba (Var.* Ti) plants as affected by the applications of nitrogen and phosphorus was made throughout its ontogeny. Mustard plants were raised in pots fertilized with nitregen and phosphorus at the rate of 10 lb. per acre and 25 lb. per acre in the form of ammonium nitrate and monocalcium phosphate. An equal number of pots were kept as control.

Respiration rate per plant (as mg. of CO_2 per two hours) increases to a maximum at the time of flowering in the life of the plant but declines later. The rate of respiration calculated, as percentage at fresh weight basis (mg. of CO_2 per 100 g. of fresh plant per two hours) and unit dry basis (mg. of CO_2 per g. of dry weight per two hours) decreases consistently with advance in age.

Percentage of total sugars rapidly increases at the time of flowering and fruit formation decreasing in later period of life. Nitrogen applications result in slight reduction in sugar content whereas it is greatly reduced by phosphorus applications.

Most of the fat accumulates in post flowering period i. e. between 85 to 115 days of plant's life. Nitrogen slightly retards fat accumulation whereas phosphorus applications greatly favours its accumulation.

Nitrogen applications at both the levels increase the rate of respiration to a considerable extent and also bring an early maximum in the respiration rate whereas phosphorus applications, in general, lower the rate of respiration of mustard plants though insignificantly.

20. Influence of Vitamins on Germination, Growth, yield and Quality of Early paddy (*Oryza stiva* ; *Var. Kuari*) and Tomato (*Lycopersicum esculentum*; *Var. Ponderosa*)

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Influence of three vitamins viz-Nicotinic acid, Ascorbic acid, and Thiamine at 0·21 mgm/L, 0·10 mgm/l and 1·00 mgm/l concentrations on early paddy and tomato plants was studied under sand culture.

Nicotinic acid, at 0·01 mgm/l concentration, was most suitable in increasing germination percentage, early root and shoot growth in early paddy other vitamins used, had very slight influence. In the cose of tomato, however, germination was improved by the use of ascorbic acid at 0·01 mgm/l.

Thiamine at 1·00 mgm/l had its greatest influence on the vegetative characters of paddy. Ascorbic acid 0·01 mgm/l proved next best.

Nicotinic acid 0·01 mgm/l was most effective in increasing the physical and chemical characters of early paddy grains. Thiamine 1·00 mgm/l, ascorbic acid 0·31 mgm/l and nicotinic acid 0·01 mgm/l, came next in order.

Physical characters, vitamin C and carbohydrates in tomato fruits were influenced by thiamine at 1·00 mgm/l. Thiamine 0·01 mgm/l, nicotinic acid 1·00 mgm/l and ascorbic acid 0·10 mgm/l stood next in effectiveness.

21. Morphology and taxonomy of 3 new species belonging to the subfamily *Prosotocinae* Yamaguti, 1958 (Fam: *Lecithodendriidae: Trematoda*)

Onkar N. Bhardwaj, *Mahakoshal Mahavidyalaya, Jabalpur, M. P.*

In this paper 3 new species, viz., *Prosotocus poroformis n.sp. Prosotocus tigrinum* n. sp. and *Mehraorchis jainiformis* n. sp. of the subfamily *Prosotocinae* Yamaguti, 1958 have been described. *Prosotocus poroformis* n. sp. is very interesting in that it has got a genital sucker (genital papilla, or "gonotyl" of the family *Heterophyidae*), as well as a distinct type of cirrus complex and a peculiar position of its testes. *Prosotocus tigrinum* closely resembles the other *Prosotocids* with asymmetrical vitelline glands (so far solely described from India), but has got peculiarities of genitalia and other morphological features. Whereas, *Mehraorchis jainiformis* n. sp. (*Mehraorchis* is another purely Indian genus with the 4th species being described here) is considered of utmost importance due to the asymmetrical nature of its vitelline glands. By studying the trends of its intraspecific variations and comparing it with the *Prosotocus* species with asymmetrical vitellaria, we can easily guess that the latter might be a more highly evolved type in a divergent evolution from the ancestral

type. Other taxonomic attributes of these species have also been discussed along with some of the ecological remarks.

22. Studies on intraspecific variations in *Tremiorchis ranarum* Mehra and Negi, 1926 (Family: *Plagiorchidae*. Luhe, emend. Ward, 1917: Trematoda), with discussion on causes and effects of intraspecific variations

Onker N. Bhardwaj, *Mahakoshal Mahavidyalaya, Jabalpur, M. P.*

The information presented in this paper records further observations on T. *ranarum* Mehra and Negi, 1926. About 105 worms, from more than 400 frogs of *Rana tigrina* species were studied and these have shown 7 interesting morphological variations which are of a haphazard or "indeterminate" type. The probable causes of these variation have been suggested on the basis of the studies of various eminent biologists. The author feels that these variations are due to genetic plasticity; and the evolutinary significance thereof has been discussed. It is felt that doing away with the pseudotaxa, like subspecies and subgenera, definitely helps in the clearing of our ideas about speciation, intraspecific variations, and hence about taxonomy as a whole.

23. Studies in stomatal frequency of some plants at Allahabad

B. M. Sharma, *Central Botanical Laboratory, Allahabad*

Salisbury (1927) has shown considerable variation in the stomatal frequency in different parts of a leaf. Morever, the increase in stomatal frequency with height may be a general feature of the herbaceous plants. An attempt has been made to trace the stomatal frequency of plants belonging to different growth forms growing at Allahabad. These are *Calotropis procera, Ipomea biloba, Pothos* sp., *Bryophyllum* sp. and *Launea* sp. The observations of the present work support the generalisation put up by Salisbury in that the stomatal frequency may vary greatly at different positions on the leaf. Stomatal frequency is higher at the base of the leaf rather than at the tip. Contrary to earlier observations of Salisbury (1927) the stomatal frequency has been observed to be irregular with height of the plant. In all the species examined there were stomata on both the surfaces. The stomatal index was higher on the lower surface in all the plants except in *Calotropis procera* and *Ipomea biloba*.

24. Chemical analysis of some desert plants and their soils

B. M. Sharma, *Central Botanical Laboratory, Allahabad*

The area of investigation centres around Churu Town in Bikaner Division of Rajasthan. The climate of this region is arid with high temperatures (max. $22.5°$—$41.6°$ C and min. $4.0°$—$28.9°$ C) and meagre rainfall $(0.0$—165.6 mm). The vegetation is mostly of herbaceous type with trees like *Prosopis spicigera, Salvadora persica* and *Zizyphus rotundifolia*, etc. The soil is sandy, light yellowish brown to dark brown and highly porous. Magnesium and calcium are found to dominate the exchange complex of soil mass and the cations fall in the following order :

Magnesium (1.67—5.26 m.e %) > Calcium (1.18—3.82 m.e %) > Potassium

(1·52—3·72 m.e %) > sodium (1·39 —3·2 m.e %). The possible source of mineral return to top soil is that of the components of vegetation supported on desert soils. The soil nitrogen content is found to range from 0·008 to 0·043 %. The chemical constitution of six plant species is listed below :

Plant species	Ca %	Mg %	P %	Na %	K %	Ash %	Silica %
1. *Prosopis spicigera*	2·43	0·38	0·13	0·36	2·59	8·56	0·55
2. *Calligonum polygonoides*	2·57	0·92	0·07	0·36	2·29	9·83	0·86
3. *Calotropis procera*	2·41	0·77	0·19	0·92	3·03	15·11	1·72
4. *Aerua tomentosa*	3·26	0·68	0 06	0·99	4·93	14·71	2·40
5. *Tephrosia purpurea*	2·00	1·03	0·49	0·87	3·38	9·96	2·19
6. *Cenchrus catharticus*	1·72	2·48	0·30	3·49	3·55	13·50	2·06

The desert plants and soils are looked upon as an integral component of desert ecosystem within which biological circulation of minerals takes place.

25. The morphology of the male Reproductive organs of *bradinopyga Geminata* Rambur Libellulidae : Odonata)

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This paper deals with the morphology and histology the male reproductive organs (both internal and external) of adult *Bradinopyga geminata* Rambur. The male internal genital organs consist of a pair of testes, a pair of vasa deferentia, a sperm-sac and a very short ejaculatory duct. The testes are a pair of long cylindrical and multilobular organs measuring 7·0 mms. in length and 0·289 mm. in thickness and occupying a part of fifth abdominal segment and whole of the sixth and seventh abdominal segmeuts on the ventro-lateral side of the alimentary canal. The vas deferens is morphologically divisible into three regions : (a) anterior thin region, (b) enlarged middle region and (c) posterior looped region. Before joining its fellow from the other side, each vas deferens forms two U-shaped loops, one lying anterior and dorsal to the other. In the middle of the ninth abdominal segment, there is a very prominent sac-like structure, the sperm-sac, which stores spermatozoa. The ejaculatory duct is a very short cup-like structure basically a prolongation of the ventral wall of the sperm-sac. Accessory glands are totally absent. The secretory function has been taken up by the columnar cells of the wall of the sperm-sac. The male genital opening is a longitudinal slit lying in the middle of the ninth abdominal segment on the ventral side in between a pair of coxites. The external genital organs consist cf a pair of supra-anal appendages, a single infra-anal appendage and a secondary copulatory apparatus on the ventral side of the second and a part of the

third abdominal segments. The last named comprises a pair of genital lobes, an anterior lamina, a posterior lamina, supporting framework, penis sheath, a pair of claspers or hamuli, penis and a penis vesicle. All these organs are lodged in a genital fossa. The supra-anal appendages are a pair of long forceps-like structures, each measuring 2·18 mms. in length and bearing a row of 7-9 minute teeth-like protuberances on the outer ventro-lateral side. The infra-anal appendage is spatula-shaped, slightly smaller in length than the supra-anal appendage and is present only in the males. The posterior margin of the anterior lamina which is divisible into two regions is excavated in the middle in the form of a bowl-shaped notch. The anterior lamina does not extend over the anterior region of the penis sheath. The supporting framework consists of a system of chitinous rods forming more or less a U-shaped structure and giving support to the genital fossa, hamuli, penis sheath and the anterior lamina. The penis sheath is a triangular scoop-like structure measuring 0·85 mm. in length. The penis vesicle is a large, somewhat hemispherical flask-like organ about 1·02 mms. long, arising in the anterior region of the third abdominal sternite. The spermatozoa are transferred to this organ from the ninth abdominal segment prior to copulation. The penis is a rod-like three semented intromittent organ whose distal segment lies bent over the proximal segment. It is sclerotized heavily on the dorsal and lateral sides but ventrally the wall is thin and membranous. The proximal segment measures 0·68 mm. in length and lies in the groove of the penis sheath. The middle segment is smallest of the three being 0·34 mm. long. The 1·105 mms. long distal segment is an elongated barrel-shaped organ narrowed proximally and distended distally. It bears the orifice of the penis which is actually situated at the end of a tube that runs from the base of the penis upto its tip.

26. Note on the external genital organs of male *Trapezostigma basilaris burmeisteri* Kirby (Anisoptera : Odonata)

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The external genitalia of male *Trapezostigma basilaris burmeisteri* Kirby consists of a very complicated but characteristic secondary copulatory apparatus locatad ventrally on the second and a part of the third abdominal segments, a pair of well developed supra-anal appendages coming out postero-terminally from the tenth abdominal segment, a single median infra-anal appendage situated between the anus and the supra-anal appendages and a pair of pear-shaped and reduced appendages, the coxites (George 1928) surrounding the gonopore on the ventral side of the ninth abdominal segment. The structure of some of these organs is quite different from that of other Libelluline species viz. *Bradinopyga geminata* Rambur, *Pantala flavescens* Fabricius, *Lathrecista asiatica asiatica* Fabricius, *Diplacodes trivialis* Rambur, *Crocothemis servilia servilia* Drury and *Brachythemis contaminata* Fabricius studied earlier and the differences can be regarded as the specific characte r of the present species.

The secondary copulatory apparatus in *Trapezostigma basilaris burmeisteri* Kirby consists of a pair of genital lobes, a genital fossa, anterior lamina posterior lamina, supporting framework, penis sheath, a pair of hamules, penis vesicle and a penis. The anterior lamina is a broad strongly sclerotized chitinous piece, notched posteriorly into a bowl-shaped structure. The supporting framework is more or less a saddle-shaped structure consisting of two lateral strongly sclerotized rods and a single weakly chitinized median horizontal piece joining the posterior basal ends of the lateral rods. This horizontal chitinous piece in this species supports dorsally the penis sheath near the base whereas in other species if

gives support to the penis sheath near its middle. The penis sheath is very characteristic and is located only in the anterior half of the genital fossa a finding contrary to that of Chao (1953). It is a strongly scooped chitinous structure divisible clearly into an anterior club-like head portion and a posterior basal portion. In other species the sheath of the penis is triangular in shape. In its cavity, the penis sheath lodges the first segment of the penis. The hamules are a pair of stout appendages visible even with the naked eyes. each hamule is a laterally compressed, and elongated chitinous piece bearing a strongly chitinized incurved hook at the distal tip. Goddard (1896) reports that each hamule is cleft distally into two divisions : an anterior spur-like portion and a posterior truncate portion. But as described above, this is not so in the present species. Tillyard (1917) states that the orifice of the penis in *Aeschna* is situated on the convex dorsal side of the second segment. But in *Trapezostigma basilaris burmeisteri* Kirby the orifice of the penis is situated on the dorsal side of the third segment slightly towards the distal end.

Each supra-anal appendage measures nearly twice the length of the infra-anal appendage and bears a few teeth-like protruberances on the ventro-lateral side. These protruberances form secondary sexual character of the male.

27. The Morphology of the Female Reproductive Organs of *Bradinopyga geminata* Rambur (*Libellulidae* : Odonata)

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This paper deals with the morphology and histology of the female reproductive organs (both internal and external) of adult *Bradinopyga geminata* Rambur. The internal genital organs consist of a pair of ovaries, a pair of oviducts, a short common median oviduct and a highly muscular set of organs termed as the 'Eighth complex.' The lateral pair of accessory spermathecal sacs and definite accessory glands are absent. The ovaries are large, elongated and yellowish-white organs measuring 17·846 mms. in length and extending dorsally to the alimentary canal from the base of the first abdominal segment upto the end of the sixth abdominal segment. Each consists of a very large number of panoistic ovarioles arranged longitudinally on the ventral side of a very large lateral oviduct which runs throughout the dorso-lateral side of the ovary. This lateral oviduct continues posteriorly beyond the sixth abdominal segment upto nearly the middle of the eighth abdominal segment as one of the paired oviducts. The common median oviduct is a very short and relatively broader duct leading posteriorly into the '8th complex'. The '8th complex' consists of a median spermathecal sac, a muscular bursa copulatrix and a ventral vagina opening to the exterior through the vulva. The bursa copulatrix is a multipurpose organ for storing sperms and serving as a copulatory pouch during mating. Its lumen is lined by a thick layer of chitin which is thrown into many irregular folds forming pouches and ridges. In the living condition of the animal the bursa copulatrix shows heart-like pulsations. The epithelial cells in the wall of the median spermatheca are glandular and contain secretory granules. The female genital opening is a large transversely elongated simple orifice situated ventrally at the junction of the eighth and ninth abdominal segments. The external genital organs consist of a pair of anal appendages and a number of vestigeal processes constituting the reduced ovipositor in the neighbourhood of the female genital aperture. The anal appendages are 1·206 mms. long, tubular somewhat conical and creamy-white structures projecting postero-laterally

from the tenth abdominal segment. Each terminates distally in a dark brown spine. The ovipositor consists of a vulvar scale, a keel-shaped ventral plate and a pair of minute red-coloured processes representing the rudiment of the median processes of typical Odonatan ovipositor. The vulvar scale is a sheath-like roughly bilobed process projecting ventrally over the vulva.

28. A note on the rooting of stem cuttings of *Justicia gendarussa* Linn.

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In order to find out optimal conditions for rooting of the stem cuttings of *Justicia gendarussa* L., following experiments were carried out in the month of March, 1960 :

Expt. I. Cuttings of uniform growth and size (1 ft. length) in four categories viz. (*i*) completely defoliated and decapitated, (*ii*) one pair of upper most leaves retained per cutting with a inflorescence. (*iii*) two pairs of leaves retained per cutting with an inflorescence and (*iv*) three pairs of leaves retained per cutting with an inflorescence were cultured in tap water in seperate 250 cc. flasks for 30 days. Water was changed daily. Twenty replicates of each categories were tried. Observations made show much earlier appearance of leaf buds and roots in the leafless series than in (*ii*) and (*iii*) categories. The cuttings of category (*iv*) did not show any development of roots. On 30the day of experiment percentage of cuttings which rooted and degree of rooting in each case were noted. These readings show best rooting response in the cuttings of leafless series, second best in the category (*ii*) and poorest in the category (*iii*) whereas category (*iv*) showed no rooting at all.

Expt. II. Two categories of cuttings viz. leafless and leafy (one uppermost pair of leaves with inflorescence per cutting) of uniform growth and size were kept for 15 days with their bases dipped in soil extract in water, which was prepared by boiling 100 g. of soil in 1 litre and then filtering it. This treatment, in both the cases, resulted in earlier leaf bud and root emergence than in the tap water with a good degree of rooting.

Expt. III. The above two categories (i. e. lefless and leafy) of cuttings were treated with two concentrations (0·33 g. per litre and 1·66 g. per litre) of KMNO$_4$ for two hours by keeping their bases dipped in the permanganate solution and then were transferred to beakers containing tap water. Rooting was seen only in leafy cuttings treated with the lower concentration of KMNO$_4$ but showing a very poor degree of rooting. Rest of the cuttings dried in a week.

29. Morphology and life history of *Artyfechinostomum indicum* (Bhalerao 1931) Jain, 1960

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The common Indian fresh water snail, *Indoplanorbis exustus* collected from Chhuikhadan pond, Suyatal and ditches in the Ghamapur area of Jabalpur, were found to be infected with cercariae of this species. The cercaria resembles closely *Cercaria mehrai* Faruqui, 1930 (=*C. Paryphostomum mehrai* Jain, 1958 ; *C. A. mehrai* Jain, (1960) and *Cercaria Palustris* Chatterji, 1932 and *C. indicae* XLVIII Sewell, 1922 except for the number of flame cells, presence of a small cuticular fold at the posterior end of the tail and number of spines in the collar.

The cercariae were allowed to encyst in the snails which were sheding them and also in other individuals of the same species of the snail. The metacercariae obtained from experimental as well as natural infections were fed to white rats. Eggs were observed in the faeces of the infected rates after two weeks of infection. Eggs were incubated in tap water having a pH. value of 6·9-7·3 and at a temperature of 30°C. The miracidia were available after 10 days. The miracidium resembles in general the other Echinostomatid miracidia. The ciliated epidermal plates are arranged in 4 transverse tiers. The first row consists of 6, the second also of 6, the third of 4 and the 4th of 2 plates respectively. There is a single pair of flame cells. The germ balls are present in the form of a compact mass in the posterior region. There is a pair of lateral penetration glands and a median apical gut (= median penetration gland). A pair of eyespots are present.

Adult parasites were recovered by feeding metacercariae, obtained from experimental as well as natural infections. It takes about 14-15 days for the metacercariae to develop into the adults in white rats. The adults obtained from the infected rats resemble very much *A. indicum* (Bhalerao, 1931). Jain, 1960, the morphology of which has been discussed in the paper.

30. Observations on Morphology of Adult, Egg and Miracidium of *Artyfechinostomum sufrartyfex* Lane, 1916

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There is no end of confusion in the systematology of the species *Artyfechinostomum Sufrartyfex* which was described by Lane in 1915 from the intestine of an Assamese girl. Bhalerao (1931) obtained this species from the intestine of domestic pigs in Bengal and he transferred it to the genus *Paryphostomum* Dietz (1909). Yamaguti (1958), Yadav (1959) and Jain (1960) have accepted the validity of the genus *Artyfechinostomum*. Jain (1960) while revising the genue *Artyfechinostomum* has included two more species in it viz. *A. indicum* (= *Paryphostomum indicum* Bhalerao, (1931) and *A. Mehrai* (= *Paryphostomum mehrai* (Faruqui, (1930) Jain, (1958).

The parasites were found in large numbers attached in the intestine of pigs at Jabalpur and on being examined were found to represent the species *A. sufrartyfex* Lane, 1915. The morphology of the worms has been discussed in the paper.

The eggs were collected by keeping the worms in physiological saline solution and by teasing their uterus. The eggs were non-embroyomated. They were incubated in tap water having a pH value of 7·1-7·3. The miracidia came out after 12 days at a temperature of 27°C. and on 10th day when the water temperature was 30°C.

The miracidium resembles, in general, the miracidia of other echinostomes. The ciliated epidermal plates are in four transverse rows bearing 6,6,4 and 2 plates respectively from anterior to posterior. There is a single pair of flame cells, a pair of lateral penetration glands and median apical gut.

The common Indian fresh water snails—*Limnaea luteola* and *Indoplanorbis exustus* were exposed for infection. The miracidia were observed to penetrate the former host.

31. Deciduous forests of Belgaum, Western Ghats

B. S. Ahuja, *Central Botanical Laboratory, Allahabad*

The paper deals with the deciduous forests of Belgaum situated approximately between latitude 15°32' N and 16°58' N and longitude 74°2' E and 75°25' E along the Western Ghats.

Geologically the area has unclassified rocks (granite, gneiss and laterites etc.), Schiests, quartzite, limestone and basalt. The soil varies according to the parent rock from which it is derived.

The climate is typically monsoonic with an average rainfall of about 125 cms.

Deciduous forests commonly occur where conditions of low rainfall, high temperature and low humidity are prevalent. The area covered by the forests in this district is 14·09 per cent of the whole area. For the present study the deciduous forests have been divided into four types : (*i*) *Teak forests,* (*ii*) *Bamboo forests,* (*iii*) *Teak-Bamboo forests* and (*iv*) *Non-Teak-Bamboo forests.*

The topographical, climatic and geological factors have a direct bearing on the types of forests. The forests are low in the eastern region where rainfall is less with high temperature in comparison to the higher forests of western region where rainfall is high with a moderate temperature.

The succession is progressive. The detailed chart showing the succession in the area is also given in the detailed paper.

32. Vegetation of Sutgatti, Western Ghats

B. S. Ahuja, *Central Botanical Laboratory, Allahabad*

The present paper deals with the vegetation of Sutgatti and adjoining areas in the district Belgaum along Western Ghats. The climate of the area is typically monsoonic with an average annual rainfall of about 144 cms. The data has been presented on basis of study of quadrat method. The size of quadrat determined by species area curve comes to 20 × 20 ft. for deciduous forests and 10 × 10 ft. for the scrubs.

With Teak as the indicator species vegetation has been classified into 2 types :—

1. *Teak forests.* 2. *Non-Teak forests.*

The climax stable type in teak forests is a community of *Teak-Terminalia* type while the Non-teak type support *Terminalia-Emblica* type. Other communities in the area are various stages in the development of these two climax communities. The scrub jungles are biotic or bioedhapic representing a secondary vegetation which, under protection, develops deciduous type of climax vegetation. The presistance of several communities in a more or less semi-permanent state is due to the aspect, nature of the soil and biotic conditions.

33. Investagations on Mycotic Infection in Cattle

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Samples of infected material and of aborted foetuses are collected from different places in Assam. The fungal isolates included *Aspergillus — Penicillium — Mucor* and *Trichopyton* types of spores and hyphal fragments including conidiophores. The sampling of air in a cowshed and in field has shown that airspores constitute the principal source of infecting units and include such types as *Aspergillus, Penicillum, Cladosporium, Alternaria, Mucor, Fusarium, Bacterium* and *Actinomycetes*. The results also show that the major changes of spore concentration depend on the weather conditions and the associated fungal flora. The concentration of spores in the air was found to be highest during or after rainy days. The spore concentration in the air of cowshed was found to be greater than that of the field. The findings are discussed with reference to animal fungal disease.

34. Seminal Roots of Grasses

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Grasses develop a crown of fibrous roots often distinguishable as seminal and nodal root systems at seedling stages. Seminal roots originate from the initials in the seed while nodal roots arise endogeneously from the stelar tissue of nodes on the stem. Methods available for seminal root culture are reviewed along with notes on relative longevity of seminal and nodal root system from the available literature. Much has been said about the introduction of grasses into desert and semi-desert parts of India without collection of data on their ecological amplitude. The present study fills up the gap with provision of ecological data on germination and seminal and nodal root behaviour of five grasses in alluvial soil. Seminal root longevity is found to be a specific character for the grasses investigated. Factors such as, soil moisture, soil texture and species competition deserve futher study for effective grassland agronomic practices either in hills or plains of India.

35. Localization of Vernalization influence

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It is now a more or less accepted fact that vernalization stimuli are received and retained in a meristem and get subsequently distributed to other meristems derived from it. The present investigation has been undertaken to determine whether vernalization effect persists when the original meristem receiving the direct stimuli is divided repeatedly.

Through the removal of apical buds on the plants and branches of *Cicer arietinum* L. raised from varnalized and normal seeds, a series of plants having either a primary, secondary, tertiary or quartenary branch was produced and the date of opening of the first flower on each of them recorded. Even the quarternary branches on vernalized plants flowered significantly earlier than their counterparts on the normal ones showing thereby that a meristem is capable of receiving and retaning the vernalization stimuli indefinitely, which increases autocatalytically with every division of its cells.

36. Thyroidal control of Radiophosphorus metabolism as studied by the effects of Thyroxine and Pituitary extract in Thiourea and Radioiodine treated Goldfish, *Carassius auratus L.*

P. N. Srivastava, *Zoology Department, Allahabad University, Allahabad*

Information concerning the endocrinological regulation of mineral metabolism in fishes is lacking. The problem is particularly interesting because the parathyroid gland which regulates the normal calcium and phosphorus content within the body in higher vertebrates is supposed to be absent in fishes. Numerous experiments carried out by the author have indicated that the thyroid has some influence over the mineral metabolism in yearling salmon. In the present investigations three groups of the goldfish *Curassius auratus* L., were treated with radioactive iodine and antithyreid drug, thiourea and the third having been kept as control. All these groups of fishes were then subjected to three different sets of treatments *viz.*, injections of physiological saline (control), extract of acetone-dried goldfish pituitary gland and thyroxine. Radiophosphorus, P-32, was then added to all the aquaria and antibiotic tetracycline was put in to eliminate any bacterial activity.

The conclusions drawn from the experiments are that radioiodine completely destroyed the thyroid follicles and so the radiophosphorus uptake was low (22%), approximately half that of the controls (45·0%). Injections of pituitary extract did not have much effect (uptake 24·6%). The injections of thyroid hormone, thyroxine, increased the uptake from 22·9 to 34·6% (50% increase). The uptake of radiophosphorus in thiourea treated fishes (26·7%) resembles that of fishes injected with iodine-131 but the injuctions of pituitary extract increased the uptake in these fishes from 26·7% to 37·5% (40% increase). The results provide confirmatory evidence that thyroid has positive influence over the calcium and phosphorus metabolism in fish, but it cannot be said definitely at present whether this control is direct or is indirect through some other intermediate agency.

37. Cytological studies of some Spaeropsidales—I. The Vacuome

R. K. Saksena *and* Dinesh Kumar, *Botany Department, University of Allahabad, Allahabad*

The origin and development of the vacuolar system in *Botryodiplodia* Sp., *Botryodiplodia theobramae* Pat, *Diplodia cajani* Raychaudhuri, and *Macrophomina phaseoli* (Maubl.) Ashby has been studied. The vacuoles at the tip of the hyphae are generally small, round or ellipsoidal bodies and further back are seen as big oval vacuoles. Except in *Macrophomina phaseoli* metachromatin is absent in all the organism of present study. Tannins are also absent in the vacuoles of these fungi. The organisms could not be stained intravitally with neutral red.

38. Cytological studies of some Sphaeropsidales—II The chondriome and nuclei

R. K. Saksena *and* Dinesh Kumar, *Botany Department, University of Allahabad, Allahabad.*

During the study of the chondriome in the case of *Botryodiplodia* Sp., *Botryodiplodia theobromae* Pat., *Diplodia cajani* Raychaudhuri and *Macrophomina* phaseoli (Maubl.) Ashby of Sphaeropsidales mitochondria in the form of granula were seen. Of the various fixatives tried in the present experiment best results were obtained

in sublime formol. These structures could be stained with 2, 3, 5 triphenyl tetra-zolium chloride in living conditions. The mitochondria could not be stained with Janus Green Höcht B when stained supravitally because of the granularity of the cytoplasm.

No nuclear division could be observed in any of the organisms of the present study. In resting stage nuclei were seen best in the material fixed in Raper's fixative. In it a deeply stained central body (nucleolus) was seen surrounded by colorless space. No chromatin thread was visible.

39. A comparative study of the neurosecretory cells in certain insects

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Neurosecretory cells have been observed in the brain, corpora cardiaca and corpora allata of many insects and the former have been attributed the important function of initiating moulting and metamorphosis and of controlling metabolism.

A comparative study of the neurosecretory cells of the brain and other nerve ganglia has been made in the imagines of three insects, viz. *Forficula* sp. (Dermaptera), *Periplaneta americana* (Dictyoptera) and *Dysdercus koenigi* (Heteroptera), and besides the brain, their presence has also been demonstrated in all other ganglia, *i. e.*, the suboesophageal, thoracic and abdominal ganglia.

In the brain of *Forficula*, neurosecretory cells of a single type and about twice as large as the neurones are distributed on all sides and not restricted only to the pars intercerebralis as generally reported. In *Periplaneta*, two types of very conspicuous neurosecretory cells are found throughout the brain but are particularly abundant in the dorsal and ventral parts. The two types of cells are similar in staining reactions but differ distinctly in their phase of activity. In *Dysdercus* also the cells are distributed throughout the brain but there is a specially prominent concentration of 14 or 15 cells on each side of the mid-dorsal line in the protocerebrum. These cells may be distinguished into two types by different staining reactions in Heidenhain's Azan and Paraldehydefuchain. About three cells in the protocerebral concentration of each side stain blue with Heidenhain's Azan while the rest stain pink and correspond with the two types of cells described in *Iphita limbata* (Nayar, 1955) and have accordingly been named 'A' and 'B' types. Cells in other parts of the brain belong to the 'A' type and so do the neurosecretory cells of the brain of *Forficula* and *Periplaneta*.

In the suboesophageal ganglia of all the three insects, 'A' type cells are present and in *Periplaneta*, in addition to cells in the two phases described in the brain, there are many cells with enormous peripheral vacuoles and with the cytoplasm reduced to mere strands.

In the thoracic and abdominal ganglia of all the species, 'A' type cells are present throughout but they are more numerous on the dorsal side and in the anterior and posterior parts than on the ventral side and in the middle. In *Periplaneta*, cells occur in the same phases as in the brain and vacuolated cells have not been observed.

40. Studies on Penicillia—I : Taxonomic Studies of Penicillia of Allahabad

B. S. Mehrotra *and* Dinesh Kumar, *Botany Department, University of Allahabad, Allahabad*

The following twenty species of Penicillia have been isolated from the soil, rotting fruits, seeds and as laboratory contaminents from Allahabad. Only 30 Penicillia have been reported from India so far, out of which one from Allahabad. The species isolated and identified by us are : *P. citrinum* Thom, *P. frequentens* Westling, *P. cyaneum* (Bain and Sort) Biourge, *P. rubrum* Stoll, *P. variabile* Sopp, *P. purpurogenum* Stoll, *P. decumbens* Thom, *P. funiculosum* Thom, *P. steckii* Zaleski, *P. rugulosum* Thom, *P. claviforme* Bainier, *P. italicum* Wehmer, *P. tardum* Thom, *P. notatum* Westling, *P. kapuscinskci* Zaleski, *P. citreoviride* Biourge, *P. corylophilum* Dierckx, *P. herquei* Bainier and Sartory, *P. islandicum* Sopp and *P. lanosum* Westling.

Except *P. citrinum* Thom all are new reports from Uttar Pradesh and *P. kapuscinskci* Zaleski, *P. citreo viride* Biourge, *P. corylophilum* Dierckx, *P. herquei* Bainier and Sortory, *P. islandicum* Sopp, *P. lanosum* Westling and *P. notatum* are new reports from India.

41. Studies on Penicillia—II : Utilization and Synthesis of oligosaccharides by some Penicillia of the Monoverticillata group

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The utilization of oligosaccharides by *P. levitum* Raper and Fennel, *P. sclerotiorum* van Beyma, *P. citreo viride* Biourge and *P. cyaneum* (Boin and Sort) Biourge was studied. The medium was chromatographically examined to detect the various sugars formed during assimilation. All the oligosaccharides except lactose were found to be utilized through a hydrolytic pathway and almost all proved to be good sources of carbon for these organisms. The hydrolytic products of both sucrose and lactose were utilised by the Penicillia tested. The utilization of glucose was faster than that of either fructose and galactose.

During utilization of maltose, it was found that all the Penicillia converted it by transglycosidation into an oligosaccharide, maltotriose with simultaneous liberation of glucose.

During the assimilation of raffinose the following hydrolytic products, viz., melibiose, glucose and fructose were formed. The utilization of glucose and fructose was faster than that of melibiose which persisted in the medium till the 15th day.

42. DDT dehydrochlorinase activity in *Protoparce sexta* (Lepidoptera)

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The present study was taken up to demonstrate the presence of the enzyme DDT dehydrochlorinase in the DDT resistant *Protoparce sexta* by following the methods of Sternburg and Kearns (1951) and other usual methods but these methods failed.

The enzyamtic dehydrochlorination of DDT and its analogues (e.g. TDE and Methoxychlor) to non-toxic products was first demonstrated by Sternburg and Kearns in the DDT resistent house fly. Subsequently they demonstrated the production of

DDE and other dehydrochlorinated products of TDE and Methoxychlor *in vivo* in several DDT resistant insects. But these workers failed ·to demonstrate the *in vitro* activity of the enzyme DDT dehydrochlorinase which is actually responsible for the breakdown of DDT and its analogues to non-toxic products in several DDT resistent insects, including *Protoparce sexta,* although, such activity had been successfully demonstrated in six other insects, in which it was also ̖shown that the enzyme forms the basis for the DDT resistance.

Several attempts were made in the present study to demonstrate the enzyme by using different co-factors, *e.g.,* CoA, Cysteine, Glutathione, DPN and yeast extract but they did not work out. But it was found that the enzyme works if the insect is chopped into small pieces instead of homogenizing. Ultimately it was found that by following the method of Chattoraj and Kearns (1958) the enzyme could be activated, by homogenizing the insect along with 3mg. of GSH in 1ml. phosphate buffer of pH 7·4.

The obvious explanation of this peculiar observation is that some substance is released during homogenization which either inhibits the activity or destroys the enzyme soon after its extraction and so it is concluded that in the present case GSH is not only acting as a co-factor but also as a protector.

43. The utilization of monosaccharides by some ascosporic *Aspergilli*

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The utilization of eight monosaccharides by *Aspergillus nidulans* (Eidam) Wint, *A. rugulosus* Thom and Raper, *A. quardrilineatus* Thom and Raper, *A. variecolor* (Berk and Br.) Thom and Raper and *A. violaceus* Fennell and Raper was studied in detail. Circular paper chromatography was employed for daily analysis of the medium. All the monosaccharides were found to be favourable sources of carbon. However, *A. variecolor* and *A. quadrilineatus* showed moderate and poor growth on galactose and sorbose respectively possibly due to failure to synthesize necessary induced enzymes.

The addition of sorbose in the medium resulted in the slow utilization of some monosaccharides *viz.,* arabinose, fructose and rhamnose but the rate of utilization of xylose by *A. nidulans A. rugulosus* and *A. quadrilineatus* and glucose by *A. variecolor* and *A. quadrilineatus* was however enhanced.

44. Studies on the Chromosomes of two species of Potamonid Crabs, *Acanthotelphusa martensi* WOOD-MASON and *Paratelphusa (Barytelphusa) jacquemonti* RATHBUN

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The cytological differentiation of sex chromosomes from the autosomes in the Potamonid Brachyurans has been a matter of controversy since Delpino (1934) reported the presence of two X-Chromosomes in the male germ cells of *Telphusa fluviatilis* and Yanagita (1944) denied the existence of such chromosomes in *Potamon dehaani.,* To investigate further in this direction two more species of the same family *Potamonidae* have been studied.

The spermatogonial complex of *Acanthotelphusa martensi* Wood-Mason consists of 88 polymorphic chromosomes, 4 V-shaped matacentric chromosomes lying at the periphery of the metaphase plate and 84 acrocentric ones ranging in size from small rods to spherular forms. In the case of *Paratelphusa (Barytelphusa) jacquemonti* RATHBUN there is no metacentric chromosome—all 132 spermatogonial chromosomes are acrocentric showing gradual diminution in size.

The bivalents of primary spermatocyte (44 in *A martensi* and 66 in *P. (B) jacquemonti*) are distributed uniformly at the equatorial plate, and in the former usually a pattern is observed whereby the smaller tetrads are surrounded by the larger ones. There are 44 and 66 chromosomes of dyad character (in the respective cases) at the equatorial plate of secondary spermatocytes, which in the anaphase divide equationally and each pole receives equal number of daughter monads.

As evident from the structure of chromosomes and the mode of divisions in both the species no chromosome showed any peculiar behaviour at any stage to be considered as the sex chromosome. The differentiation of heterochromosomes in decapods chiefly Potamonid crabs and cytotaxonomical relationship have been discussed.

45. Carbon requirements of some ascosporic members of *Aspergillus nidulans* group

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Suitability of different types of carbon sources, viz., sugars, sugar alcohols and organic acids, for the growth of *Aspergillus nidulans* (Eidam) Wint, *A. rugulosus* Thom and Raper, *A. violaceus* Fennell and Raper, *A. variecolor* (Berk. and Br.) Thom and Raper and *A. quadrilineatus* Thom and Raper was found out. All the monosaccharides proved to be favourable sources of carbon for the growth of the fungi under investigation. *A. quadrilineatus*, however, showed poor response when cultured in medium containing sorbose. Of the disaccharides sucrose and lactose proved to be good carbon sources, while maltose, supported less growth. Raffinose, the only trisaccharide used to the present study was also found to be a good source for the growth of all the fungi tried. Starch and dextrin supported good growth while inulin showed poor growth. The sugar alcohols were found to be excellent sources of carbon. All the organic acids employed in the present study were found to be almost useless for the *Aspergilli* under investigation.

64. Nitrogen requirements of some ascosporic *Aspergilli*

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Nitrogen requirements of *Aspergillus nidulans* (Eidam) Wint, *A. rugulosus* Thom and Raper, *A. violaceus* Fennell and Raper, *A. variecolor* (Berk. and Br.) Thom and Raper and *A. quadrilineatus*, Thom and Raper were studied under controlled conditions. All the ammonium compounds were poorly utilized by the present fungi due to the preferential utilization of ammonium ions. The behaviour of the present fungi towards the choice of different organic nitrogen compound varied diversely. Of the five mono-amino monocarboxylic acids serine proved best for all *Aspergillus*.. Leucine was a poor nitrogen source for *A. nidulans*, *A. rugulosus* and *A. quadrilineatus*, moderate for *A. variecolor* and good for *A. violaceus*. Alanine was good for *A. rugulosus*

A variecolor and *A. violaceus* and for the rest it was moderate source. Valine was moderate for *A. nidulans* and *A. quadrilineatus*, good for *A. rugulosus*, *A. violaceus* and poor for *A. variecolor*. Glycine was poor for *A. quadrilineatus*, moderate for *A. nidulans* and for the rest it was a good source. Of the two monoamino dicarboxylic acids glutamic acid was found to be better than aspartic acid for most of the Aspergilli. Sodium nitrate, sodium nitrite, calcium nitrate and magnesium nitrate, acetamide and peptone were also good sources.

47. Two new strigeids of the family *Diplostomidae Poirier*, 1886

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Two new species, one belonging to the genus *Glossodiplostomum* Dubois, 1932 and the other to the genus *Balbophorus* Dubois, 1935 collected from the Indian snake bird *Ahinga melanogaster* are described and their systematic position discussed.

Glossodiplostomum duboisilla n. sp. is the second known species of the genus because the validity of two species described by Vidyarthi (1938) under this genus is doubted by Dubois (1938). New species differs from the genotype *G. glossoides* in the size of the body, oral and ventral sucker being of equal size, pharynx round and the disposition of vitellaria being in two separate bands throughout their length.

Bolbophorus indiana n. sp. is the second Indian species described of this genus. It resembles the genotype in several major characters including the presence of a genital bulb in the bursa copulatrix. But it differs from *B. confusus* in general shape of the body, absence of prepharynx ; shape of the ventral sucker, hold-fast organ, genital organs and the adhesive gland also differs. New species shows all those differences which Vidyarthi (1938) has mentioned for his species *B. orientalis* Vidyarthi from the genotype.

48. Studies on Mucorales IV

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The following ten species of Mucorales have been isolated from Allahabad soil and animal excreta.

1. *Absidia spinosa* Lendner
2. *Absidia orchidis* (Vuillemin) Hagem
3. *Rhizopus arrhizus* Fischer
4. *Rhizopus nigricans* Ehrenberg
5. *Actinomucor elegens* (Eidam) Benjamine & Hesseltine
6. *Cercinella simplex* Van Tieghan
7. *Mucor luteus* Linnemann
8. *Mucor lausannensis* Lendener
9. *Cunninghamella echinulata* Thaxter
10. *Cunninghamella bertholletiae* Stadel.

Absidia orchidis (Vuillemin) Hagem., *Actinomucor elegans* (Eidam) Benjamine and Hesseltine and *Mucor lausannensis* are new reports from India.

49. On the Pore-Tubes of the Lateral line System in *Hilsa ilisha* (Ham.)

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The pore-tubes of the lateral line system in *Hilsa ilisha* are enormously branched into a system of external canaliculi which run in the thick fibrous layer of the skin. Such branched pore-tubes are present in all the cephalic lateral line canals and in the anterior remnant of the trunk canal. Each pore-tube opens into the respective canal by a single aperture at its base while it opens to the external environment by numerous minute pores of its terminal branchlets. The branching of pore-tubes of *H. ilisha* seems to surpass all such, but a few, cases recorded by previous workers.

The branching of the pore-tubes of the lateral line system is a very unusual and peculiar feature. But unfortunately its functional significance to the fish has not been discussed hitherto. It seems to the author that the branching of the pore-tubes is a special device for increasing the intensity of vibration of the waves which act as stimuli to the lateral line sense organs. Moreover, such a mechanism has been shown to be of adaptive value in relation to the habit and habitat of *H. ilsiha*.

50. Sulphur requirements of some members of *A. nidulans* group

V. P. Agnihotri, *Botany Department, University of Allahabad, Allahabad*

The sulphur requirements of *Aspergillus nidulans* (Eidam) Wint, *A. rugulosus,* Thom and Raper, *A. violaceus* Fennell and Raper, *A. variecolar* (Berk and Br.) Thom and Raper and *A. quadrilineatus* Thom and Raper was studied. The organisms were able to utilize sulphur both from inorganic and organic sources. Of the inorganic compounds magnesium sulphate supported maximum growth of *A. variecolor*, *A. quadrilineatus*, sodium sulphite of *A. nidulans*, sodium sulphate of *A. violaceus*. Among the organic compounds cystin supported maximum growth of *A. rugulosus* and for the rest it was a favourable source. Thiourea and zinc sulphate proved to be poor sources of sulphur for all the Aspergilli under investigation. Control (medium without sulphur) did support little growth of all the aspergilli.

It was also found that there was no correlation between the amount of growth and sporulation. It was observed that under similar conditions of growth, absent or showed a wide variety which culminated in excellent sporulation.

All the Aspergilli shifted the pH of the medium towards alkaline side.

51. Observations on the Life-history of *Centrococcus insolitus* Green (*Coccidae* : Homoptera)

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Stages of this Coccid are covered with a white granular substance, inhabiting almost all the parts of Brinjal plant but the younger stages prefer the ventral surface of the leaves while the adult females prefer tender twigs and shoots. Its life-history consists of six and four stages in male and female respectively including the adult instars. The first nymphal stages are almost straw-coloured and have a pair of small antennae, three pairs of legs and a pair of small black eyes. Their

head, thorax and abdomen are broadly jointed. The first three instars, common in both male and female, are also similar in general appearance and differ only in size. These last successively for about five, four and three days in April-May. In the female, the third stage moults to enter the adult stage, which also does not differ much from the previous instar in form. In the male, the third stage secrets a white cottony pupal case in approximately 24 hours and then moults inside it to enter into the fourth or the prepupal stage. The prepupa is pale yellow and has a pair of small, transparent and immobile antennae extending back laterally up to the bases of the first pair of legs, a pair of small black eyes, a pair of small wing-buds and legs. This stage lasts for only a day at the end of which the fourth moulting takes place and the insect enters into the pupal stage lasting for three days. The last moulting gives rise to the adult male which stays in the pupal case for further 24 hrs. The males emerge in the evening and start flying in search of females. The average span of life of the male is three to five days during which it copulates with several females. The females form white egg-sacs in which they lay several pale yellow oval eggs numbering approximately 150-300 eggs per egg-sac.

This insect is visited by few Coccinelids and their larvae which make the egg-sacs of this Coccid their dwelling place thus devouring the eggs and the younger-stages, a few hymenopterus flies which lay their eggs in the body of the younger stages, and small red ants. These have not yet been identified but the former two exercise much control over the increase of their population.

The life-history is not checked in any part of the year and during most months all the stages occur simultaneously; but in the winter, i.e., in the months of November to February, the population consists predominantly of eggs and females and other stages virtually disappear in November and December. This seems to be due to excessive prolongation of the incubation period.

52. Studies on the Structure and Behaviour of chromosomes of certain Teleostean fishes. I. On the chromosomes of *Saccobranchus fossilis* (Ham) and *Clarias magur* (Bloch)

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The chromosome survey has hitherto been carried out in only one species, *Parasilurus asotus* of the family *Siluridae* by Nogusa (1951). The present paper deals with the chromosomes of two other siluroids viz. *Saccobranchus fossilis* and *Clarias magur*. The number of chromosomes of *Saccobranchus fossilis* is 56 in diploid in the spermatogonia and 28 in haploid in the primary and secondary spermatocytes. The number of chromosomes in *Clarias magur* is 50 in diploid in the spermatogonia and 25 in haploid in both the primary and the secondary spermatocytes. In these two fishes the diploid complement is composed of acrocentric and metacentric chromosomes. In both the fishes the separation of the chromosomes of the first division always takes place synchronously and neither precession nor succession could be observed in any chromosome.

Though considerable work has been done genetically on the sex-determining mechanism in fishes the question of the sex-chromosomes has not yet been cleared up cytologically in any species so far. In both the cases described above the author could not detect any chromosome throughtout the meiotic divisions which, from its shape or behaviour, could be characterised as the sex chromosome.

53. Studies on the Spiracles of two species of Grasshoppers, *Sphingonotus rubescens* (**Walker**) **and** *Chrotogonus trachypterus* **Blanch**

S. N. Prasad *and* K. M. Srivastava, *Zoology Department, Allahabad University, Allahabad*

Ten pairs of segmentally arranged spiracles are present in both the species of grasshoppers, two pairs being located on the sides of the thorax and eight on the abdomen. All the ten pairs are functional : (holopneustic). There are two fundamentally different types of spiracles : those in which the occluding valves are external, and those in which the valves are internal; the thoracic spiracles have external valves while those of the abdomen have internal. The first, or mesothoracic spiracle is located in the intersegmental membrane, between the prothorax and mesothorax and is normally covered completely by the free lateral edge of the pronotum. This is by far the largest spiracle of the ten. The opening into the tracheal trunk is larger than that of any other spiracle. In *Sphingonotus rubescens* (Walker) the anterior and posterior lips are large, and a round circular structure is present on the posterior side of the peritreme. But in the case of *Chrotogonus trachypterus* Blanch the lips are relatively shorter. The soft inner face of the anterior lip is serrated and the round circular structure on the peritreme is absent.

The second, or metathoracic, spiracle is located on a small triangular plate, situated just above the mesocoxal cavity. In *Sphingonotus rubescens* (Walker) the anterior and posterior lips, the spiracular opening and the occlusor muscle are shorter than those in *Chrotogonus trachypterus* Blanch.

The first abdominal spiracle lies in the slight depression of the auditory cavity on the anterior rim of the tympanal sense organ. In *Sphingonotus rubescens* (Walker) both the sclerotized walls of the abdominal spiracle are semi-circular in out-line and of these the movable wall is larger in size than the immovable one, while in *Chrotogonus trachypterus* Blanch, both the walls are nearly equal in size. Long hair-like structures are present at the external orifice of the immovable wall and completely cover the external opening of the spiracle. This spiracular opening of *Chrotogonus trachypterus* Blanch, is larger than that of the former species. The remaining seven pairs of spiracles are all alike except in size, and are similar to the first abdominal in structure in both the species of grasshoppers.

54. Status of the Genus *Testisaculus* **Bhalerao, 1927** (*Echinostomatidae*: **Trematoda**)

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The generic name *Testisaculus* was proposed by Bhalerao (1927) for a trematode which he recovered from the lizard, *Uromastix hardwicki* and named it *T. indicus*. The latter has been assigned to different genera by different authors. Bhalerao himself (1931), while publishing the fuller account of this species included it in the genus *Paryphostomum* Dietz, 1909 and described it as *P. indicum*. Baugh (1950, referred to this, and suggested the synonym between *Te tisaculus* and *Paryphostomum*) while Baschkirova (1941) had erected another generic name *Reptiliotrema* far Bhalerao's species. Yamaguti (1958), however, revived the original genus *Testisaculus* for it, and suppressed *Reptiliotrema* as its synonym. Yadav (1959) and Jain (1960)transferred it under the genus *Artyfechinostomum* Lane, 1915. But Premvati (1959) restored *Reptiliotrema*, when she described *R. primata* a new species of trematode from *Rhesus* monkey. The author is of the opinion that Bhalerao's species does. not belong to

Paryphostomum which is a valid genus. It also does not appear to belong to *Artyfechinostomum*. As such, it should be included in the genus *Testisaculus* which name has priority over *Reptiliotrema* and is, therefre, considered valid.

55. A Revision of the Genus *Mehraorchis* Srivastava, 1934 (Trematoda : *Lecithodendriidae*) with a re-description of *M. ranarum* Srivastava, 1934

Onkar Nath Srivastava *and* Ekramullah Khan, *K. N. Government Degree College, Gyanpur (Varanasi)*

Mehraorchis ranarum Srivastava, 1934 has so far been reported from the cysts in the body cavity and from the bile duct and gall bladder of Indian frogs. At Gyanpur, it has been recovered from the rectum of the host, which is thus revealed as a new habitat for this fluke. A study of its morphology records the presence of a prepharynx and shows the range of variation in its characters.

The ratio of the two suckers and the extension of uterine coils beyond the terminal ends of caeca have been observed to be characters which vary also with the rigors of fixation. On account of their variable nature they do not serve for specific differentiation and, therefore, lead to the conclusion that *M. tigrinarum* Gupta, 1954, the only other species described under the genus and the genotype, *M. ranarum* Srivastava, 1934 are synonymous. An amended generic diagnosis is offered which encompasses these variations.

56. A new trematode *Psilochasmus Mehrai* n. sp. of the family *Psilostomidae* Odhner, 1913

A. N. Gupta, *K. N. Government Degree College, Gyanpur (Varanasi)*

Of all the species described under the genus *Psilochasmus* Luhe, 1909, the new species *P. mehrai* comes very close to *P. indicus* Gupta, 1957. These two species differ from the rest of the species of the genus in having the genital opening pre-bifurcal. The new species can, however, be distinguished from *P. indicus* by the greater distance which seperates the genital opening from the intestinal bifurcation. Besides this the distance seperating the two testes and their shape and the wide characteristic belt of vitellaria in the post testicular region mark *P. mehrai* as a distinct species.

Posterior extension of the cirrus sac, anterior extent of the vitelline follicles, length of the prepharynx and the position of the ovary in relation to the anterior testis.

57. DDT residues on treated Pea vine silage and the Cows' milk with special reference to the methods for its analysis

A. S. Srivastava, *Entomologist to Government, U. P., Kanpur*

DDT residue studies have been carried on treated pea vines, stack silage, canned and shelled peas and also on milk samples from cows fed with DDT silage.

DDT residue on fresh pea vines treated with DDT dust containing 1% to 5% at the rate of 35 to 50 lbs. per acre found to vary from 2 to 13 parts ppm. when

dusted with ground dusting machine. Pea fields when dusted with 2% to 5% dust at the rate of 35-40 lbs. by aeroplane were found to contain DDT 2-3 ppm. When the pea vine put into the stack, the DDT residue in this silage varied from 5·7 to 0·3 ppm. Thus, the amount of DDT was reduced in the pea vines from the time of dusting till the consolidation of silage in stack *i.e.,* from 13 ppm. to 0·3 ppm. within a period of eight months. When seven diary cows fed on average daily ration of 37 lbs. of DDT treated silage for a period of 5 months, DDT residue in the milk was found to be from 0·6 to 0·2 ppm. Thus, these residues are so small that no health hazard would seem to exist from using or drinking the milk.

This paper also describes various modern methods used for micro determination of DDT in the pea vines, silage and milk.

58. Bionomics and control of Paddy stem-borer, *Schoenobius incertellus* Wlk.

A. S. Srivastava *and* H. P. Saxena, *Section of the Entomologist to Government, U. P., Kanpur.*

Schoenobius incertellus Wlk. belongs to Order Lepidoptera, family *Pyralidae* This does not occur as a serious pest of paddy in Uttar Pradesh as a maximum of 5-20% of paddy plants have been found to be infested with this pest. Late varietie. of paddy are more severely attacked than the early maturing ones because the pess gets an opportunity to multiply in appreciable numbers by the time early varieties get mature. The external symptoms of the presence of the borers in young plants is the gradual fading and the ultimate death of the central shoot due to the consumption of the internal tissue of the stem by the caterpillar. If plants are attacked during the flowering stage the earheads dry up without the development of grains, causing white earheads which can easily be spotted out in the fields.

The incubation period of egg varies from 6-8 days. The tiny young caterpillar feeds on the tender leaf tissue for about a couple of days and reaches the stem when it bores aud enters. It goes on feeding the internal tissue descending down towards the roots. The larval period lasts for 20-30 days. The full fed caterpillar is pale yellow in colour and measures about an inch in length. It pupates inside the tunnel of the stem for 9-12 days and emerges as a moth through a hole previously made.

A number of modern synthetic insecticides including DDT, BHC, Parathion, Endrin, Dieldrin and Diazinon have been tested in various concentrations and dosages against this pest on field scale; spraying the crop with a mixture of 0·05% Diazinon: 0·75 lbs. of actual Endrin per acre four times during the season including one at nursery stage, before transplanting, proved most efficacious in reducing the infestation of the stem borers and has given mean percentage of living plants as 98·14% $\pm$ 0·52 C. D.

59. The "Preferred Temperature" of Castor capsule-borer larvae

A. S. Srivastava *and* G. P. Awasthi, *Section of the Entomologist to Govt., U. P., Kanpur*

It was observed during the course of the study of various stages of the life history of castor capsule and seed borer, *Dichocrocis punctiferalis* Guen., that larvae

enter into quinscent stage in the months of December, January and first half of February when the atmospheric temperature ranges from 12°C to 20°C. In order to over-winter the caterpillars coil up and rest inside the hollow seeds, the contents of which had been eaten away by them during their active period. They also seal the opening of the capsule by their web.

Because the insects are cold-blooded, so within narrow limits their body temperatures are the same as that of their surroundings. The chemical reactions of metabolism, therefore, automatically retard as soon as the temperature goes down beyond threshold limit. In order to find out this critical temperature limit, resting caterpillars of all stages in growth were taken in batches of 20 and were exposed for a period of 6 hours each day to temperatures 150°C to 24°C and it was observed that there was no change in the activity of the resting caterpillars. The day they were exposed to 25°C they resumed activity after 3)-40 minutes and also started feeding. The temperature was further increased up to 32°C and it was noted that further increase in the temperature had no marked change in the activity of the caterpillars. Fully grownup caterpillars also pupated after feeding for three to four days when exposed to temperatures above 25°C. Thus, the optimum temperature for the active life of caterpillars of *Dichocrocis punctiferalis*, Guen., lies at 25°C and above. This finding was further confirmed when the atmospheric temperature of the room reached 25°C, all the resting larvae became active and after feeding for 3 to 7 days pupated.

60. The effect of Temperature on the activity of Honey Bee

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The honey bee, *Apis mellifera gandhiana* Nougiera Netto is a social insect of great economic importance. It is, therefore, necessary that it should be protected from the hazardous effects of the insecticides. The temperature dependence of the cholinesterase (ChE) activity of ground heads of honey bee has been determined by noting $\triangle pH/time$ at 20°, 30°, 35° and 40° (Centigrade). It has been found that the maximum ChE activity exists at 35°C.

61. The free Amino acid constituents of the adult (Pink) desert locust, *Schistocerca gregaria* Forsk.

A. S. Srivastava, G. P. Awasthi *and* B. P. Gupta, *Section of the Entomologist to Government, U. P., Kanpur*

Studies on nutritional physiology with special reference to the free amino acid constituents of the adult (Pink) desert locust, *Schistocerca gregaria* Forsk., were undertaken. The technique of unidimensional and two-dimensional paper chromatography has been employed for the determination of various free amino acids.

Butanol—acetic acid—Water (40:10:50) was employed as a solvent to run unidimensional chromatograms. Two dimensional chromatograms were first run in Butanol-Acetic Acid—Water (40:10:50) and then in buffered phenol. The presence of a particular amino acid was arrived at by comparison of the position occupied by the unknown amino acids with the standard graph of the RF values of known amino acids. These identifications were confirmed by superimposition technique and it was found that in all there are 12 free amino acids present in the body of the adult (Pink) locust. Out of these 12 amino acids, 9 have been identified as (1) Lysine (2) Serine (3) Glycine (4) Glutamic acid (5) Threonine (6) a Alanine (7) Proline (8) Methionine or/and Valine (9) Leucine.

Further work is in progress to determine the identity of the three remaining amino acids found present in the adult (Pink) locust.

62. Biology and control of *Chilo Zonellus* Swinhoe, an important pest of *Juar* and maize

A. S. Srivastava *and* B. P. Gupta, *Section of the Entomologist to Government, U. P., Kanpur*

The stem borer of *Juar*, *Chilo zonellus* Swinhoe, has been found attacking millets specially *Juar* and maize throughout India and is responsible for their poor yield in grain and fodder. The adult is straw-coloured nocturnal moth. Females lay, on an average, 226 dull creamy eggs along the midribs of the leaves which hatch in 5-8 days. The larva, after hatching, enters the stem and feeds on internal tissue. Larval period varies from 18-42 days according to the season during its active period. Pupation takes place within the stem and the adult moth emerges from pupa in 5 to 8 days. The pest carries over to next season throught he larval stage.

A field insecticidal trial has been conducted during the year 1959-60 with seven treatments *viz.* (A) Spraying with 0·25% Endrin+1% ovicide (B) Spraying with 0·25% Endrin alone (C) Spraying with 0·075% Diazinon+0·25% DDT W. P. (D) Spraying with 0·1% Diazinon (E) Spraying with 0·1% Lindane+0·25% DDT W. P. and (F and G) Control (No treatment). The dosage of insecticidal sprays were used at the rate of 80 gallons per acre. The data of the results was statistically analysed and it was found that spraying the crop with 0·25% Endrin+1% ovicide at the rate of 80 gallons per acre gave significant result when compared with control, the mean number of affected plants per 50 plants being 8 in the treatment and 14·13 in the control with a critical difference of ± 3·29 and is proved to be the best of all treatments tried against this pest.

63. Biology and control of *Indarbela quadrintata* Wlk.

A. S. Srivastava, *and* M. S. Siddiqi, *Section of the Entomologist to Government, U. P., Kanpur*

The caterpillar of *Indarbela quadrinotata* Wlk. (Order Lepidoptera, family Arbelidae) is one of the most serious pests of guava, *Psidium guajava*, in Uttar Pradesh. The attack of this pest on tree is characterised by the presence of long,

winding, thick, blackish or brownish ribbon like masses composed of small chips of wood and excreta, both of which intermixed with the help of adhesive material secreted by the caterpillar.

The female moth has a wing expanse of about 40 m.m. and male of about 36 m.m. The moths copulate within 25 hours of emergence from the pupa. The female lays eggs in clusters of 15-25 eggs under loose bark of stem and branches or near cracks and crevices in the month of June. The period of incubation is about 10 days and larva on emergence starts making ribbon like mass and hides under it, feeding on bark, and bores into the stem and branches as it grows older. The caterpillar is nocturnal in habits and remains concealed in the tunnel during the day. It comes out of its tunnel at dusk and feeds on the bark and the under-lying tissues keeping itself hidden under the cover of ribbon-like mass. The larval stage lasts for 9-10 months. The caterpillar when fully grown measures about 50 m.m. in length and is of greyish brown colour with dark greyish brown patches on the dorsal and lateral sides of each segment. Before pupation the caterpillar stops feeding and webs up a case of fine chips of wood excreta with the aid of adhesive material, inside the tunnel, and pupates in it from the last week of April to the second week of May. The pupa is redish brown in colour and measures about 25 m.m. in length. The pupal stage lasts for about 28 days and emergence of moth from the pupa is completed by the third week of June. Only one generation of the insect in a year has been recorded in U. P.

The pest has been successfully controlled by injecting a mixture of ethylene glycol and kerosene oil (one part of ethylene glycol mixed with three parts of kerosene oil) into the tunnels with the help of a syringe and then sealing the opening of the tunnels with mud.

SYMPOSIUM ON ECOLOGICAL PROBLEMS IN THE TROPICS

INAUGURAL SPEECH

By

Dr. M. S. Randhawa

President of the Academy

LADIES AND GENTLEMEN,

I am very happy to have this opportunity of giving some preliminary remarks on this symposium on 'Ecological problems in Tropics'. This symposium has been mainly organised due to the efforts of Dr. G. S. Puri. Dr. Puri and Prof. R. Misra are the two pioneers of ecology in this country, and the interest they have taken has placed this subject in a prominent position in the biological sciences in India. I was very happy to see recently a book on 'Indian Forest Ecology' by Dr. Puri in which, for the first time a comprehensive and lucid account of the vegetation of this country has been given. We live in segments of a vast country and our views regarding the vegetation of the country are based on what we see. There is such a diversity from alpine and temperate vegetation in the Himalayas, to the Tropical vegetation of Kerala, and Madras. I have been familiar with the vegetation of Northern India, particularly of the Western Himalayas, where I had an opportunity of frequent travelling. When I was in the Western Ghats, Coorg and the forests in Kerala, I was baffled by the strangeness of plants and could not identify even four or five trees. From this angle I feel that the study of Dr. Puri is very valuable and will be of great interest to all of you who want to know the vegetation of India.

Prof. Misra has carried on studies on the autecology of weeds, which is of great practical importance from the point of view of agriculture. We have a large number of weeds in this country, which take a lot of nutrition, with the result that they cause enormous agricultural losses. Recently weedicides have been discovered, and are being used to eradicate weeds. The pernicious weed *Carthamas oxycanthus* was successfully controlled by the use of weedicides in Delhi villages. Here also we want to know about the life history of the weeds, the period of flowering, seed setting or the viability of seeds. We have got to study different types of weeds and lay down priorities according to their perniciousness to agriculture. These studies will greatly help agriculture.

On going through the summary of the papers that are being presented before this symposium, I feel that we need a careful planning of ecological research. With our limited resources in regard to finance, and manpower we should select projects for research carefully. In the paper by Champion, he has rightly emphasised that priority should be given to research bearing directly on the major needs

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of humanity. The autecology of weeds requires urgent attention and we should draw a coordinated research programme. This would also be a contribution to the agriculture and the country. I will now briefly refer to some of the papers and give my remarks :

There is a paper on trace elements of the soils of India by Dr. K. Lakshminarayanan and Dr. Puri. Here I would like to tell you that this type of work is already going on in a chain of soil testing laboratories which have been set up during the Second Five Year Plan all over India, and they are already working on this problem of trace elements, and some interesting results have already accrued.

In Punjab Citrus orchards planted during the last 5 years, do not bear fruit. Much benefit has been derived by spraying the plants with zinc.

Another subject, which is very important is that of plant introduction in the arid zones. There is a paper from the Arid Zone Station at Jodhpur which deals with the introduction of suitable trees. This certainly makes a good contribution to the economy of arid areas.

I find another paper on the studies of mangroves by Mr. S. S. Sidhu, which is of practical value. He has suggested that paddy cultivation is not successful in these areas.

We should limit our interest in specific projects and make a list of problems and lay priorities and should suggest schemes, which should be carried on in the universities.

With these remarks I have much pleasure in a inaugurating this symposium and wish it great success.

REMARKS BY THE PRESIDENT OF THE SECTION OF BIOLOGICAL SCIENCES

By

Prof. M. D. L. Srivastava

Head of the Zoology Department, University of Allahabad

LADIES AND GENTLEMEN,

Before we proceed with the reading of papers received for the symposium, I take this opportunity to propose a hearty vote of thanks to Dr. Randhawa for inaugurating the symposium. He has found time to join us in spite of a very busy programme. He is a renowned botanist and a well-known scientist, besides being a very able administrator. He has made certain observations regarding the way the symposium might have been organised and suggested that we should have used the symposium to focus attention mainly on the question of food shortage and the ways of increasing food production. There is no denying the fact that it is a serious problem. All the same I owe an explanation for what we decided to do, as one of the organisers. Firstly on account of shortage of time at our disposal, a thorough scrutiny of the papers received for the symposium was not possible and we have included practically all the communications that we received for this purpose. Secondly we had decided to make the symposium a broad-based one. Ecological work is being carried on in the research laboratories and the universities, and in the latter particularly, so long as research work is being carried out on sound lines intellectually and academically, it is allowed to go its own way. It is not possible, and in my opinion not desirable, to restrict ourselves to problems of economic importance only. With this background, naturally we could not think of shutting off papers of comparatively academic interest from the symposium. But of course we shall bear in mind what Dr. Randhawa has said this afternoon and shall give it due weight when we happen to organise another symposium of this kind again. Once again on your behalf as well as mine, I thank Dr. Randhawa for the trouble he took to come here and inaugurate the symposium.

CONVENOR'S REMARKS

By

G. S. Puri

Director, Central Botanical Laboratory, Allahabad

The science of tropical ecology is still in its infancy. Most of our ecological concepts are based on life in temperate climates. Like all other modern biological sciences, ecology also originated in Europe and America and soon attracted the attention of botanists and zoologists from other regions. Thus, great strides were made in the beginning of this century in plant ecology and animal ecology in temperate regions of Europe and America. While plant and animal ecologists worked side by side in distinct realms sometime or the other, their work converged in the environmental studies and it was here that the climatologist, soil scientist, geologist, geo-morphologist and others came into closer contact with people working in plants and/or animals; and gave ecology a more holistic outlook. The comprehensive studies of organisms in relation to the factors of the environment helped in the formulation of basic concepts of ecology, such as succession and climax. It became clear only recently that all animals including man are dependent on plants and the social and economic behaviour of human communities are to a great extent determined by the vegetational status of the region. The plants, animals and human beings were recognised as interdependent units in the eco-system.

It became increasingly difficult to classify vegetation into formations and associations, as distinct units by characteristic or exclusive plant species even in temperate regions. The 'forest types' of Cajander did not work in tropical climates. Here again, emphasis has to be shifted to the eco-system concept.

Meanwhile, scientists working in forestry, agriculture, land and water conservation, etc. realised that their fields of work were more or less applied ecology. They became, therefore, greatly interested in the fundamentals of ecology and the application of ecological principles in proper land use planning was first used on a large scale in America. From now onwards ecology became an important concept in all spheres of man's activity in relation to plants and animals. To quote Sir Edward Salisbury. "The chief contribution of ecology is that it is not a discipline apart, possibly not even to be regarded as an individual subject, but rather an attitude of mind that endeavours to integrate the contributions from many so

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called subjects into an interrelated whole. It is thus that the agriculturist, the forester, the soil surveyor, the irrigation specialist, and the students of land utilisation and erosion, all find themselves sooner or later making common cause with the investigators of plant communities and these in turn demanding more and more of the aut-ecologist and plant physiologist."

The eco-system concept found further emphasis from the work of the Russian ecologists, headed by Sukachev. He proposed the term Biogeocoenose for eco-system and emphasised greatly the importance of this concept in the study of tropicol lands, especially. With a view to formulate clearly the concept of eco-system a symposium on this subject was held at the Ninth International Botanical Congress at Montreal in 1959, where ecologists from different regions of the world presented their views and the following recommendations were adopted for use in future ecological studies :—

(1) "In view of the concern in forestry with both vegetation and the land on which it grows and is perpetuated, and recognising the ecological bonds uniting the two (forest and site), it seems appropriate that the general idea of the eco-system be adopted as a fundamental concept for the description, classification and investigation of forests.

(2) Unit forest eco-system can be defined and delimited spatially and temporally in various ways, and recognition of the distinction between vegetation centred and land centred eco-systems is necessary, if misunderstanding is to be avoided. Attention to the mutual and reciprocal use of both vegetation and land in setting the boundaries of useful eco-system units is recommended. Complete descriptions of eco-system units, in terms of both biota and physiography, is strongly urged in order to assist correlative studies by others.

(3) As neither the forest vegetation (phytocoenose) alone nor forest site (ecotope) alone is an adequate indicator of the ecosystem whole, classification ought to be based on significant features of both. Only in this way can the dynamic similarities of eco system be established. Techniques of ordination and gradient analysis will prove useful in detecting similarities and differences between eco-systems.

(4) As a field wherein there is continual transformation of energy and matter with the production of organic materials, each eco-system can be characterised by functions, i.e., by the form and intensity of its own processes. An understanding of the dynamics of eco-systems is essential if they are to be controlled; such understanding will also refine classification and assist in the definition of types of maximum use for forestry. Therefore, the study and analysis of forest eco-sys-

tems should be directed to their functional processes as productivity systems, as well as to the ecology of their parts and not only to their composition and structure.

(5) Eco-systems are geographic entities, and they are not readily systematized without reference to the earth's surface. A system of regional classification on the basis of homogenity of biota and landform, provides the necessary framework within which description and classification of forest ecosystems is given precision. Also within biotic-physiographic regions the inductive development of useful principles is facilitated.

(6) Although, approaches to forest eco system typology will probably continue to take different lines from area to area due to geographic individualities and to differences in purpose and in available knowledge, it should be possible to formulate an acceptable system of concepts, and a fundamental terminology, that will permit the ready exchange of methods and results between different workers in this field. It is recommended that particular attention be given to this as the necessary basis for international cooperative work."

The UNESCO have provided the lead in ecological studies of tropical lands, especially of the arid zone and the humid tropics. The arid zone project, which developed earlier brought together plant and animal ecologists with scientists dealing with the environment and now a network of experimental stations and institutions have developed in the desert parts of the world to study the interaction of plants and animals with the environment and their reciprocal effects on the human societies. An institute has recently been set up by the Government of India with the cooperation of UNESCO at Jodhpur, where specialists in plant, animal and human ecology have started work. It is hoped that this ecological team will enrich our knowledge of the desert habitat.

The humid tropics projects started later and a number of symposia covering vegetation and environment were held, the first one in 1956 in Ceylon and the second and the third in Indonesia and Ivory Coast, respectively, in 1959; and the fourth symposium on the impact of man on vegetation was recently held in New Guinea. In these symposia the importance of man in eco-system has been realised and it has been pointed out that the use of vegetation, animals and land by man according to non-ecological principles would result in the destruction of the human species itself. The tropics especially of the Indian region are characterised by monsoon rainfall, with distinct periods of rainfall and dry weather, alternating. There is an alternation in the period of plenty and period of scarcity and if the land is not covered with proper type of vegetation, there will be intense erosion during rainy season and desiccation during the dry period, resulting in the destruction of

land fertility. The tropical lands are the most poorly developed regions of the world, where the problem is not only of a well developed industry, but also of a well balanced agriculture. In order to feed the teaming millions of the tropical lands, it has been considered necessary that some of the areas may be put under agriculture and industry after clearing forests. How far this will help in the ultimate advancement of the people of the tropical lands is difficult to say and unless we have ecological information available from the eco-system as a whole, it will be very risky to take up any large scale projects of forest clearings in these areas.

The humid tropics project of the UNESCO have, therefore, as also the arid zone project, emphasised that detailed ecological studies on the eco-system should be conducted on an international basis in tropical lands. Benefitted by experience in the Indian region (see *India Manual of Plant Ecology*, by R. Misra and G. S. Puri, 1956, English Book Depot, Poona ; and *Indian Forest Ecology* by G. S. Puri, 1960, Oxford Book & Stationery Co., Scindia House, New Delhi), it was considered important that some organisation for eco-system studies in the tropics be formed on an international basis. The International Society for Tropical Ecology inaugurated in early 1960 at Bombay with a world wide membership have started the publications of useful information in tropical ecology. An *Eco-system Proforma* (published by Oxford Book & Stationery Co., New Delhi) has recently been prepared by the Society with the cooperation of botanists, zoologists, foresters, soil scientists and is now in the hands of ecologists of this region. This proforma gives in clear terms the points on which data are to be collected on a world wide basis.

Already, some work according to the lines prescribed in the proforma has been started in the Central Botanical Laboratory, where information is being collected habitat-wise. The Indian region has been divided into a number of units, such as the arid zone, the humid tropics, the Central Indian sub-arid Plateau, the Himalayan region, the Indo-Gangetic plains, the dry parts of western India and wet parts of Eastern India. The studies are started right from the beginning with the preparation of floras, floristics, quantitative estimation of vegetation, successional studies, etc. leading to the study of the soils, the biochemistry of the plants, the relationship of plants and animals and their interaction with man and his environment. Some of the papers on these subjects are presented in the present symposium and it will be useful to discuss the importance of such a common approach in the study of life in the tropics. In addition to papers from the Central Botanical Laboratory a number of useful papers have been presented, from other parts of the country in animal ecology, soil relationships and plant ecology. There is a paper on socio-economics of the Himalayan people and some on fish ecology. Very comprehensive studies on the mangroves from all its aspects is the subject of another paper, presented to this symposium. I would specially mention the paper on organic matter in physiology of

land fertility increases by Dr. N. R. Dhar, which I am sure will be of a tremendous interest to the ecologists gathered here. Due to short time we could not get many papers from foreign scientists. However two from Prof. Davis of Florida and Sir Harry Champion from Bangkok are before you. They are extremely useful contribution outlining problems in tropical ecology.

This symposium is, therefore, in the chain of symposia that are being organised by the UNESCO and the International Society for Tropical Ecology and would, I believe stimulate further detailed and intensive ecological studies according to the eco-system proforma that has been prepared. It is hoped that in the course of time, we will be able to collect all the information necessary for economic planning of tropical lands.

In the end, I may mention that a number of foreign countries, notably the U. S. A., U. K., U. A. R. and Indonesia have shown a great interest in this symposium. The presence in our midst of Dr. Rife of the U. S. Embassy, who has especially made this visit to be with us at this symposium is a sign of the growing interest of the American Ecologists in tropical lands. They were the pioneers in Temperate Ecology with stalwarts like Cowles, Clements, and Weaver. I, therefore, take a great pleasure to record our indebtedness to Dr. Rife for the trouble he has taken along with Mrs. Rife to attend this symposium. I am grateful to Dr. M. S. Randhawa—a unique combination of a scientist, artist and an administrator to kindly inaugurate this symposium. He has taken a great interest in ecological studies and I am personally very thankful to him. To Dr. Shri Ranjan we are beholden in many ways. He has been a guiding spirit to us in all our work. I would like also to add my gratitude to members of the Symposium Committee and my colleagues and assistants in the Central Botanical Laboratory ; to Dr. R. Misra, Prof. N. R. Dhar, Prof. R. N. Tandon and many other friends for making this symposium so well attended and representative.

SYMPOSIUM ON ECOLOGICAL PROBLEMS IN THE TROPICS

ABSTRACTS OF CONTRIBUTED PAPERS

Problems on Tropical Ecology

John H. Davis, *University of Florida, Gainsville (U. S. A.)*

Tropical regions, and particularly the tropical climate parts of India, Pakistan, and Burma are very varied in respect to their lowland and upland topography, seasonal rainfall and temperature, soils and rocklands, and surface and parmanent water conditions. The basic ecological problems are to determine how the types of vegetation, the wildlife and animal communities, and the human populations and their customs and enterprises are affected by these differences and the many combinations of their variables. This can be the objective of the whole scope of ecology, both the basic and applied aspects.

But their are much more pressing problems. These involve the human factor of use and control over the most altered regions where many problems of land use, management and health are so important. The empasis should be placed on applied ecology, or on basic research that will lead to direct application. Some of the applied and basic problems are related to : forest management and re-forestation or afforestation ; grassland and range management; watershed conservation and erosion control ; wildlife preservation and management ; and more effective control of certain diseases of man and other animals. In addition some better management and use of dry areas, and, in contrast, the flooded and wetland areas are needed. For each of these problems the time for contributions by ecology is short as population pressure and increased human needs accelerate.

Training of young scientist and the applications of the trained ecologists need direction toward management of natural resources of many kinds, especially the renewable resources, such as forests, grasslands, wildlife, and water. New and better ecological investigations and studies should be coordinated toward the most pressing of the particular problems of the kind referred to above.

Tropical problems in ecology are not essentially different from those of temperate regions and may be solved in the same manner, except that the needs for solution are more pressing in many tropical regions because of the excessive mis-management of the land and water areas over much of the tropics. Therefore, there is little time left for the luzury of the pure science or academic approach to ecology. The ecological research and applications should be productive toward human betterment soon, and toward some aspects of long-term conservation for future human use and enjoyment. Some productive ecological studies should include ; restoration to better use of semi-desert areas, deforested areas, and game and other wildlife ; watershed and flood control ; insect and worm control of those that carry or are diseases. Particular autecology studies of such plants as teak *(Tectona)* and sal *(Shorea)* and animals, such as the elephant, lion, antelopes, deer, water birds, jungle fowl, and many food fish could contribute to their better use, management and conservation. A great number of "tropical" diseases stem from mosquitoes and worms and ecological studies of these would aid in their control. Also ecological studies of man himself and his village and other communities is sorely needed to select certain maladjustments that might be remedied in future societies, if not at present.

Trace Element Survey of Tropical Soils of India

K. Lakshminarayanan *and* G. S. Puri, *Central Botanical Laboratory, Allahabad*

Trace elements like iron, manganese, copper, boron, zinc, cobalt, molybdenum etc. present in small concentrations in the soil are known to have a profound influence on plant growth and metabolic processes. Little work of a coordinated nature has been undertaken in India to survey the distribution and availability of the trace elements in different types of soils in India. The paper discusses the metabolic functions of trace elements in soils with special reference to methods of assay. Indian work on trace element distribution in soils is reviewed with a plea for a systematic national survey to assess the micronutrient status of Indian Soils.

Chromosome Numbers and Habitats with Special Reference to Tropical Plants

R. P. Patil *and* Krishna Ghosh, *Central Botanical Laboratory, Allahabad*

When in a species groups differ genetically and are adapted to different habitats, they are called ecotypes (Turesson). When ecotypes differ in chromosome number, their selection by different external conditions can easily be studied.

As the grass *Poa alpina* climbs the Tatra mountains in Poland, it gains in chromosome numbers and tends to reproduce asexually (Skalinska). The higher Chromosome numbers are here correlated with asexual reproduction which is more effective at the upper altitudes. In the Indian *Ottelia alismoides*, when diploids and polyploids occur in the same pond, the diploids are marginal and the polyploids are in deep water on account of their larger size (Sundar Rao).

There is some evidence that polyploids occur at the colonising margin of the expanding species, where new habitats are met, *e.g.*, in *Biscutella laevigata* (Manton) and *Cuthbertia graminea* (Giles). While S. India (the centre of origin) has diploid, tetraploid and hexaploid races of *Ottelia alismoides* only hexaploids have reached the Gangetic Plains (Sundar Rao).

The highest percentage of polyploids is found in perennial herbs that are an important element in cool temperate and subarctic floras (Stebbins). Tropical forest is predominantly diploid (Janaki Ammal). When such forest is cleared open habitats are formed that are invaded by herbaceous perennials, especially grasses like *Heteropogon contortus*. Such widely distributed species tend to have ecotypes of varying chromosome numbers.

Tischler's observations suggest a high percentage of polyploids in halophytic habitats. Preliminary observations from this Laboratory (Sidhu) have demonstrated that *Suaeda monoica* with a more restricted distribution is a diploid whereas the more widely distributed *Suaeda nudiflora* is a tetraploid.

Photoperiodic Influence on Growth, Development and Distribution of Perennial Plants

J. K. Choudhury, *Central Botanical Laboratory, Allahabad*

Photoperiods are known to profoundly influence growth and flowering of a large number of annual plants. But it is less known that day length also effects growth and reproduction as well as distribution of a considerable number of woody species.

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This is primarily due to the scanty information available regarding the behaviour of perennials to different photoperiods, since perennials are seldom used as experimental meterial for obvious reasons that they are time-taking and difficult and also that the economic possibilities of such work appear less important and obscure. If some informations are available in respect of a few plants which grow in temperate, alpine or arctic climate practically nothing is known of those which grow in tropical regions. It is necessary that such informations are gathered of tropical plants also in view of the fact that properly understood and utilised, this knowledge may be of great help in tree-breeding, shortening of juvenile period, plant introduction etc. and thus may be of enormous value particularly to forestry and silviculture, with consequent economic possibilities.

A short review is given of those perennial plants in germination, extension growth, breaking of dormancy of bud, flowering time etc. of which are known to be affected by photoperiods under experimental conditions. Instances are also cited where introduction and distribution of plants are also influenced by photoperiods that prevail in nature.

Ecological Aspect of Nature Conservation at Khasi Hills of Assam

D. C. S. Raju, *Botanical Survey of India, Shillong*

The demand for increasing food production has necessitated a correct appraisal of our natural resources and the ecologists in India are interested in the study of the vegetation in different parts of the country and the application of ecological principles to soil conservation. The present paper briefly reviews the works done at this centre with special reference to the problems of Khasi hills.

Assam is known to have a very rich flora and this has been described in detail by Kanjilal and Bor. Floristic accounts of distinct areas in this region are given in the publications by the workers at the centre. The author has attempted phytosociological methods in the studies. The work of Thimann on the physiology of trees, experimental studies by Clausen *et. al.*, autecological studies by Misra and others, statistical methods of Greig-Smith are of importance to the study of the present problem. The following, in brief, are discussed in the paper:

1. The fertility status of the sacred grooves, pine forests and grasslands of the region, with a view to laying down principles of conservation of the haditats.

2. Possibilities of land use for the cultivation of Eucalyptus, Cacao and Coffee at the lower elevations near Nong Poh.

3. Eradication of the weed *Eupatorium adenophorum* and introduction of valuable species in the ecological niche.

4. Ecology of *Sphagnum* bogs and *Nepenthes khasiana* heaths near Jawai.

5. Study of the biological flora of the climatic formations.

The progress of work has shown that (a) the climatic control of the vegetation of Cheerrapunji, (b) edaphic control of Mawphlong and Shillong, and (c) biotic control in Umsaw-Barpani areas are some of the ecological aspects of nature conservancy. A plea for the establishment of a humid tropic ecological research unit is put forth in this connection.

Ecological Problems in the Western Himalayas

J. S. Singh *and* M. K. Wali, *Central Botanical Laboratory, Allahabad*

Hole exactly five decades back stressed the need of ecological research in economic forest problems. This need was further emphasised by Troup, Champion, Bor and others. To investigate the ecological problems in Western Himalayas, Puri and his co-workers conducted studies at several places, viz. Bashahr, Chakrata, Tehri Garhwal, Kulu and Kashmir.

Twentynine communities of conifers, oaks and mixed oak-conifers in Bashahr Himalayas have been reported by Mohan & Puri and by these studies these authors conclude that one or the other species of oak forms the climax vegetation. Thus *Quercus ilex* is the climatic climax at lower altitudes, *Q. incana* and *Q. dilatata* form the climax at a little higher and *Q. semecarpifolia* at higher altitudes, making thus lower, middle and upper oak zones. On glacial moraines however, *Pinus wallichiana*, *Cedrus deodara* and pure *Abies* forests are predominant. While studying the succession of oak-conifer forests in Chakrata, Puri and Maini came to the conclusion that previously oaks formed the climatic climax but later on due mainly to biotic interference in the non-glaciated regions and Pleistocene glaciation in other parts, oaks were replaced by Silver fir, spruce, deodar and blue pine. The studies of Gupta, Gupta and Singh in Garhwal Himalayas have lent further support to the above conclusion. Puri and Wali working in Kashmir have reported remarkably similar occurrences, Pleistocene glaciation being seemingly responsible for the wiping out of oaks.

As regards the soil not much work is available to warrant any safe conclusion. However, the work so far done indicates that Himalayan soils belong to the categories of brown earths, podsols and gleys. Taylor, Mahendru, Mehta and Hoon described five main types of soil in Kashmir and Kulu, viz. brown earth type under deodar and spruce, podsol type under deodar, chir and blue pine. immature podsol type under spruce, chir and blue pine, rendzina type under deodar and gley type under spruce forests. Puri & Gupta described features of podsol, brown earth and immature soil types in relation to their vegetation. Studies of soil under different forest communities in Bashahr Himalayas (Puri & Gupta) show a good relationship between exchangeable calcium and organic matter content. Soils under *Quercus semecarpifolia*, *Abies webbiana* and *Pinus wallichiana* communities appear to be similar as far as their parent material is concerned, the differences in surface layer being due to vegetational developments. Working on soils of Chakrata Himalayas Puri & Maini recognised four groups on the basis of chemical studies and altitude group I, supporting *Pinus roxburghii*, group II supporting *Pinus wallichiana* and *Quercus incana*, group III supporting *Cedrus deodara*, *Picea morinda* and *Quercus dilatata* and group IV supporting *Quercus semecarpifolia* and *Abies pindrow* communities.

Literature is lacking on the studies in the relationship of humus status and vegetal cover. Suri endeavoured to classify some groundflora communities on the basis of the depth of humus in some forests of the northwest Himalayas. The data recorded by Singh in Bashahr Himalayas show higher humus content in soil profiles under *Quercus semecarpifolia* than those under coniferous communities. Studies of Puri and Gupta in Kulu show some good relationship between humus status and vegetation.

The authors are at present engaged in the analysis of leaf and soil samples from various regions of Western Himalayas.

A review of these studies has brought to surface some very interesting problems which need immediate attention by ecologists, foresters and other botanists in general. The problems on which work may be taken up are:

1. Regeneration of deodar and silver fir in dry zones of upper Bashahr, regeneration of deodar in whole of Kashmir and related places.

2. Extension of studies of succession in ravine areas and other vegetation types.

3. Steps to introduce broad leaved species particularly oaks for proper conservation of soil and water in Kashmir and other places.

4. Afforestation to check soil erosion.

5. To study in detail soil and vegetation relationship especially humus status of soils under different forest communities.

The paper carries in detail the points mentioned above.

Population Differentiation in Indian Plants

P. S. Ramakrishnan, *Deptt. of Botany, Meerut College, Meerut*

The adaptively differentiated populations within the species or ecotypes are very well known to modern ecologists through many studies beginning with the works of Turesson. Ecotypes have been recognised on the basis of climate and geography or soil factors.

India with its wide range of climatic conditions and vegetational types ranging from the desert vegetation of Rajasthan to the wet evergreen forests of Eastern Himalayas and Western Ghats in relation to rainfall, with tropical, temperate and alpine forests in relation to temperature and altitude, offer vast scope for investigation on climatic races. The outstanding studies of Clausen and co-workers, in America, have shown, for example, the existence of chains of climatic ecotypes in a number of perennial species ranging from the sea level to above the timberline in California. Studies of this nature are lacking for this country.

The demonstration of the existence of edaphic ecotypes implies a level of ecotypic differentiation within the species besides the climatic and geographic levels. Misra has demonstrated the presence of two ecotypes in relation to soil calcium in *Lindenbergia polyantha*. The present author also could show edaphic ecotypes in *Euphorbia thymifolia* Linn., in relation to soil calcium, in *Euphorbia hirta* Linn. and *Echinochloa colonum* Link. in relation to moisture level of the substratum and in *Setaria glauca* Beauv. in relation to texture of the soil, moisture content and topography of the substratum. Except for these, very little work has been done in this country along these lines. This aspect of experimental ecology if pursued further in this country will throw new light on the pattern of ecotypic differentiation of plants in relation to climate and soil factors.

Soil Nitrogen Deficiency with special Reference to Nitrogen-fixing Algae

K. Lakshminarayanan, *Central Botanical Laboratory, Allahabad*

Soil nitrogen deficiency is one of the major problems facing agriculture in India and is intimately connected with our increased food production targets under the five year plans. The inadequacy and high cost of fertilizers is one of the chief bottle-

necks in our attempts to bring newer areas under cultivation and maintain high levels of agricultural production in areas rapidly declining in nitrogen. Large scale culture of nitrogen-fixing algae like *Tolypothrix tenuis, Cylindrospermum sphoerica, Anabaena cylindrica* etc. *in situ* in the soil holds great promise for maintaining high soil nitrogen levels in agricultural and horticultural lands in India.

Soils and Edapho-Vegetational Relationships in Central India

S. C. Pandeya, *Central Botanical Laboratory, Allahabad*

Soils of India have been mostly classified from the points of view of (cf. Raychaudhuri, 1959) : geological nature of the underlying rocks; suitability of the soil for certain crops; nutrient status and mechanical composition of surface and sub-soils; morphological and physical properties of the soils in connection with irrigation and afforestation projects or agronomic purposes; pedological classification and lastly for land use. Although good deal of work has been done on the above lines but it mainly pertains to agriculture. Detail study of soils under forests and grasslands and their correlations has been very little attempted in this country. There is, therefore, an urgent need of taking up soil studies of forests and grasslands on regional bases.

Edaphic controls of vegetation has been largely emphasised 'by many workers. By means of available data on Central India the edapho-vegetational relationships of a number of forest types and grasslands have been shown.

The paper also gives a short review of the various soil types found in Central India. Importance of geological relations have also been indicated.

It has been concluded that many of the forests in the area are edaphic types and in others the composition varies with soils. However, further detail studies are required to emphasise the points.

Glasslands in the area are only bio-edaphic types.

Preliminary Studies on Earthworms in Relation to Soil

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The controversial role of earthworms in soil is reviewed. By using pure cultures of *Pheretima posthuma* studies were made on various aspects of the castings, namely, total nitrogen and percentages of calcium carbonate and organic matter, and were compared with similar studies on soil. Results indicate that the rate of defaecation in *P. Posthuma* is seven to eight times its body weight per day. There is a marked increase in the percentages of calcium carbonate and organic matter, and a slight increase in total nitrogen· in the castings as compared to soil. The technique eliminates two errors, viz., contamination by other earthworm species and enrichment due to the decay of dead worms.

Some Observations on the Prospects of Mass culture of Chlorella in India

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The unprecedented increase in the growth of the human population especially in the underdeveloped parts of the world like India, has put a tremendous pressure on the scientist to bridge the gap between agricultural production and consumption,

In the search for newer avenues for augmenting the food production, mass culture of algae like *Chlorella* appears to be very promising as a cheap source of food for human and animal consumption. Work carried out in countries like Japan and Isreal has shown that the biological value of the proteins from *Chlorella* compares very favourably with animal products and superior to soy beans. The vitamin content has been shown to be higher than most vegetable food sources. In the tropics, which possesses an ample supply of sunshine water and carbon dioxide (from animals and plants)— the basic ingredients for photosynthesis, mass culture of algae like *Chlorella* and *Scenedesmus* is likely to open a new and fascinating line of approach to the problem of food inadequacy and protein malnutrition. The Central Botanical Laboratory has recently started preliminary spade work in this line.

Ecological Problems in the Tropics—Erosion VS Vegetation in the Tropics

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The phenomenon of erosion, its relation to vegetal cover and some of the Indian works on this aspect have been discussed. Ecological studies of eroded localities both in new and old alluvium of Varanasi have been made. Climate, the types and intensity of erosion, formation of gullies and gorges, and the vegetation both permanent and seasonal together with the successional relationship have also been described and discussed. Selection of species for conservation purpose based on the experimental data seems to show that growth of *Saccharum munja* and *Alhagi camelorum* should be encouraged on the new alluvium. The former has been found to be capable of checking over 96% of the soil erosion. Underground parts of *Saccharum munja* alone account for 92% reduction in erosion *Alhagi camelorum* is good in summer against wind erosion. On older alluvium the most commonly and heavily grazed grass *Cynodon dactylon* which is most abundant amongst the ground vegetation is found to be capable of checking about 95 ; of the soil from getting eroded, if grazing is effectively checked. However, the conservation value drops to about 7.5 % if the shoot is clipped, as in the case under grazed condition.

Ecological Perspective on Grasslands

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The vegetation of the world is broadly divisible into tropical and temperate forests on either side of the equator. Forests, grasslands and deserts are the principal biomes recognised, where the trinity of plant, soil and animal factor (including man) react and interact in a given climate.

Grasslands of the world are categorised as Savannah grasslands, grassland-Steppe, Desert scrub and finally alpine grasslands. These types have developed with the demands of soil, climate and operative environs. There is a paucity of legumes among these grasslands all over the world. These are either edaphic or biotic in origin with the exception of natural grasslands in New-Zealand and Africa. Regeneration of tree seedlings is a slow process in temperate grasslands while in tropics, it is quick, resulting in a forest when the grasslands are excluded from fire and grazing animal.

In India, retrogression from a forest to desert occurs through intermediate stage of grasslands. Ecological approach and scientific management of grasslands both in plains and hills, must be taken up to prevent encroaching desert conditions in the neighbourhood of Rajasthan.

Grasslands of India are specialized units of landscape with graminaceous plants forming major proportion of the vegetation. These are perceptible either as forest fillings, marginal areas of forests or grazing meadows of plains. As a result of grassland survey sponsered by Indian Council of Agricultural Research, eight major grassland types are recognised, four from the hills and four from the plains, based on different grades of soil texture.

Plants like *Butea monosperma*, *Holarrhena antidysenterica*, *Woodfordia floribunda* and *Lagerstroemia parviflora* are avoided by cattle and these serve as indicators of heavy grazing in the hills. Over-grazed grasslands of Bengal are occupied by *Careya herbacea* and in Madhya Pradesh, *Xanthium stumarium*. Populations of forbs like *Cassia occidentalis*, *Cassia auriculata*, *Cassia tora* and *Crotalaria medicaginea* are indicators of degraded village pastures of plains. *Capparis aphylla* is found on eroded tracts of West Delhi.

Grasses are found to be fair indicators of soil conditions. *Saccharum nerenga* is the dominant grass on soil most favourable for the growth of 'Sal'. *Phragmites. karka* and *Arundo donax* are indicators of grounds which are too wet for all but a few swamp species like *Bischoffia javanica* and *Putranjiva roxburghii*, *Imperate cylindrica* tends to grow on cleared areas where the soil is a heavy clay.

Local patterns of *Dichanthium* grassland are illustrated from the desert areas and Gangetic plains. Stratification is the occurrence of organisms or their parts at more or less definite levels. It is usually applied to above ground parts, but it is also characteristic of underground parts, both roots and rhizomes. This aspect of study has been illustrated by the root development data of *Dichanthium* grassland on Gangetic alluvium. The influence of grassland upon the physical and chemical properties of soil is receiving more quantitative study than a decade ago, especially in relation to improvement of soil fertility and control of erosion.

Responses of grasses to defoliation, calcareousness, phosphate and sodium nutrition deserve further study to improve the productivity of pastures and their fertility levels.

Problems in Autecology of Weed Flora of India I.   Ecology of Achyranthes Aspera Linn.

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Like synecology autecologyof individual plants is of great interest in the tropics becausea number of plants are of medicinal and other values. In this paper autecology of *Achyranthes aspera* Linn., a medicinal plant is given.

This species is a herbaceous annual weed of way sides and waste places. The soil analysis data do not give any clue to the preference of any type of soil. The length of the spike has been found to be of a very variable character. The seeds of *A. aspera* have an average weight of 4·5 mg. The plants thrive well in association with *Cassia tora* and this has been explained as due to the protection given to the former in such areas against exposure and grazing (cf. Mall & Arzare, 1956). Majority of the seeds have a complete dormancy period of $2\frac{1}{2}$ to 3 months. A few of the fresh seeds germinate, but the radicle just comes out, and further growth does not take place. This is perhaps due to the lower temperature in winter months. It has been observed that the percentage germination is higher in light than in darkness. Further more, the amount of light does not matter in germination. The reproductive capacity, stomatal frequency of 'Sun' and 'shade' leaves, osmotic pressure of the plant sap, seedling morphology, etc., have also been recorded.

A number of species have been worked out in the laboratory of Banaras Hindu University. These are *Crotalaria medicagenia, Eclipta alba, Euphorbia thymifolia* and *Argemone mexicana* and other spp. These studies show a need for planned research work in this subject.

Studies on Mangroves

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Mangroves constitute a type of habitat forming forests in estuaries, salty marshes and muddy coasts, between high tide and low tide levels occurring in creeks and lagoons of tropics, extending outside the tropics proper to a limited extent only. The areas show an annual rainfall range of 26-200" and average annual maximum temperature of 80 89"F. The soil is coastal alluvium of the recent or Pleistocene Period. As originally suggested by Schimper the mangrove forests of our planet fall into two chief sub divisions, the Atlantic type or western type and the eastern type. The group is comprised by about 20 natural orders numbering about 70 species including some halophytic herbs and allied sanddune species. The species belonging to families Rhizophoraceae, Verbenaceae, Sterculiaceae, Euphorbiaceae, Combretaceae and Palmae are comparatively of much more importance as regards their protective and productive role. These are the so called 'Himalayan guards of the coast' and 'builders and guardians' of the coastal land. In India the total area under mangrove vegetation is about 17, 80,000 acres.

The review of the previous work and the present preliminary studies opens new problems for the understanding of this peculiar habitat in the field of ecology, cytology and cytogenetics, anatomy, physiology and embryology.

The quantitative ecological studies on different areas in India show that *Avicennia alba* and *A. officinalis* Linn. mixed with *Acanthus ilicifolius* Linn. may both be the pioneer species and in still other cases, on the newly formed alluvial patches (within a period of about 50 years) the pioneer encroachers are some of the grasses including *Myriostachya wallichii*.

The cytology has shown that the mangrove species have comparatively higher chromosome numbers as compared to the corresponding mesic members of the same genus or the same family. The polyploids are definitely more suited to the extreme conditions and have better potentialities to grow in new habitats. Culture experiments are in progress to elucidate this particular point of interest. It is to be seen whether there exists any relation between the distribution of species and its chromosome number and structure.

The anatomy of mangroves shows a combination of characters, those of hydrophytes in the underground portion and those of typical xerophytes in the aerial portion. The abnormally elongated hypocotyl in the seedling shows a typical stem structure through most of its length and the change from the root to stem structure is rapid and abrupt in the region just above the junction between the root and hypocotyl. The total area occupied by the conducting tissue in tidal plants is said to be larger than in the non-tidal plant species.

Mangrove species have a high osmotic pressure varying from 26 to 46 atmosphere. The transpiration is equal or even lower than in the glykophytic tropical plants. The osmotic pressure is due to the high salt-concentration in the soil. Stomatal index varies from 1·5 (*Ceriops candolleana*) to 22 (*Acanthus ilicifolius*) and

tomatal frequency from 50-60 (*Ceriops candolleana*) to 850-950 (*Carapa moluccensis*). The studies show that the stomatal index and stomatal frequency varies with the genus or a family i.e. constant in different-species of the same genus with small variations. Generally the stomata are present on the lower surface only. It may be remaaked that stomatal index and stomatal frequency is controlled by genetic factors in mangroves and the character may be residing in the cytophasm or some of the chromosomes and in part by the environs causing small variations. The humus content varies from 1·25 − 1·61% and organic matter from 2·10 − 2·21%. The pH of the soil show a range from 7·63 − 8·50 in *Sonneratia acida* and *Avicennia alba* communities. The leaf analysis of the different species show that there is a positive relation between ash and sodium and negative between calcium and potassium.

The development of embryo in *Sonneratia* is of *Capsella* type. The plants show vivipary and hypocotyl elongates abnormally. Probably it is a result of higher salt concentration in the habitat and may have developed in the remote past as a result of this edaphic factor and may have been imprinted in the genomes of a particular species of mangroves.

The species relation of the different continents is discussed.

Paddy cultivation is not very successful in mangrove areas as it depletes the soil of its organic matter which results in the production of empty panicles. Drainage leads to a more yeild but on the whole agricultural practices are not very encouraging.

Study of Aspergilli and Penicillia in the Rhizosphere of some Crops

B. S. Mehrotra, Dinesh Kumar *and* V. P. Agnihotri, *Botany Department, University of Allahabad*

Investigations of the fungus flora of the rhizosphere of crop plants provide useful data of ecological and taxonomic importance. Out of all groups of fungi Aspergilli and Penicillia occur in largest number ins oils including the rhizosphere soils. A systematic study of Aspergilli and Penicillia of India has been undertaken under the guidance of the senior author and these groups of industrially important fungi are being isolated from all possible situations and from different regions of the country. The present paper deals with the isolation of these fungi from the rhizosphere of some important cultivated crop plants, *viz.*, *Cajanus cajan*, *Triticum vulgare*, *Pisum sativum*, *Arachis hypogea*, *Solanum tuberosum*, *Brassica campestris*, and *Cicer arietinum*. The following ten species of Aspergillus and 9 species of Penicillium were isolated : *A. niger* van Tieghem, *A. niger* van Tieghem, mut. *Cinnamoneus* (Schiem) n. comb., *A. flavus* Link, *A. panamensis* Rap er and Thom, *A. luchenensis* Inui, *A. rugulosus* Thom and Raper, *A. nidulans* (Eidam) Wint, *A. fumigatus* Fresenius, *A. tamarii* Kita, *A. carneus* (V. Tiegh) Bloch, emend., *A. utus* (Banier) Thom and Church, *P. notatum* Westling, *P. frequentans* Westling, *P. herequei* Bainier and Sartory, *P. steckii* zaleski, *P. citreo viride* Biourge, *P. purpurogenum* Stoll, *P. rubrum* Stoll and *P. variabile* Sopp.

It has also been observed that the pH in the region of rhizosphere was lower and moisture content was higher than in the soil away from it. Further a larger number of these organisms were found in the rhizosphere of young seedlings than in the soil. Evidence has been presented for the possible role of exudates from the roots being reponsible for this behaviour of the microflora.

Ecological Studies on the Vegetation of the Himalayas—A Retrospect and Prospect in view of the Mapping of Vegetation

Raj Kumar Gupta, *French Institute, Pondicherry*

The mapping of vegetation in the tropical countries, in recent years has assumed a great importance. These maps not only give an idea about the vegetation, but their importance in climatology, town planning, irrigation, landuse planning and building engineering cannot be overlooked.

A comparison of the existing maps of other countries of the world reveal that at present there is no uniformity to the approach of mapping tropical vegetation. Recently the French Institute of Pondicherry has started the mapping of vegetation according to the International method, on the lines of Prof. Gaussen of the Toulouse University and have completed their first sheet covering the south of India at one millionth scale.

The present author has been engaged in the exploration of some parts of the Western Himalayas, during the last few years, and during the studies felt that with regard to some factors in Himalayas our knowledge may be regarded as that of *terra incognita*. In this paper attempt have been made to bring forth the lacuna in our knowledge of the ecological conditions and vegetation of Himalayas with reference to the mapping of the vegetation. It has been observed that generally the lists of plants from various areas have been made by various authors without giving much regarding the ecological conditions (climate, soil, geology and biotic factors) and the types of vegetation. It is, therefore, considered that if proper emphasis is laid on these factors by individual workers, while making studies on the vegetation of the Himalayas, it would be possible to map the vegetation of Himalayas in greater details when such maps are made.

The Importance of Physiological Studies on our Knowledge of Ecology of Tropical Air-breathing Fishes

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The subject of aerial respiration in the fishes is of interest to the biologists from many points of views. It provides an example of a fundamental change in the functioning of one of the main physiological systems of the body. It is of special interest from this point of view, because it is a change which has occured very frequently and in many different ways. It is also a change which must have occurred in the sequence of adaptations which made possible the migration of fishes from the water to land.

The most remarkable feature of adaptations of fishes to aerial respiration is the fact that the great majority of fishes so adapted live in shallow tropical freshwater with few exceptions.

The air-breathing fishes comprise a heterogenous assemblage of forms belonging to diverse families. Ecologically, they can be divided into four main associations (i) fishes of pools, marshes, and sides of streams ; (ii) fishes of torrential streams ; (iii) fishes of estuaries ; and (iv) marine fishes.

It is only in exceptional circumstances, where the environment or the fish's habit make aquatic respiration impossible or inefficient and the fish have evolved

organs adapted for breathing atmospheric oxygen. The exceptional environmental circumstances in which this occurs are (*i*) the water is liable to deoxygenation, (*ii*) the water is liable to dry up in periods of drought, or (*iii*) fishes that have habits which lead them to migrate from the water at times.

These facts suggest that a preliminary step in the migration of fishes on the land in the evolution of terrestrial vertebrates was the development of aerial respiration in some such habitat as the tropical waters, while the fish was purely aquatic, and in response to the conditions of this environment. A further step in the series of changes leading to the migration was probably the habit of passing periods of drought in some semi-aquatic habitat.

Plant Introduction in the Arid Zone of India

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The subject of this paper is singularly appropriate for that portion of India which lies between 24° & 30° North latitude to 69° & 78° east longitude occupying the eastern extremity of the north tropical desert belt which extends from the Atlantic coast of Africa through Sahara parts of Arabia, South Persia & Baluchistan to India, covering an area of about 3,36,000 square kilometers. The Inter-relation between climate, soil and vegetation of the arid zone of India is discussed at great length and the prospects of plant introduction from the world homoclimes in order to increase the present low productivity potential of the area has been suggested. A comparison between phytoplasticity & climatic analogies has been made and a scheme for introduction of tree and shrubs species both for productive and protective values taking climatic homologues as an essential pre-requisite for plant introduction in arid areas has been drawn up.

Recent Advances in Fish Ecology in India

S. M. Das, *Zoology Department, Lucknow University*

The investigations of Day, Hora, Mookerjee, Das and others have laid the foundations of Fish Ecology in India. The *bionomical studies* of Hora and the bio-ecological studies of Das have added a new chapter to Fish Ecology in India. The ecological balance between dissolved salts, detritus, plankton, littoral and benthic fauna and fishes has been elucidated in India for the first times; the correlations between hydrological factors and plankton; between hydrological factors and benthic; and the correlations, between hydrobiology and fisheries have all been recently investigated.

Most predaceous fishes live in the paralimnic region and show modifications mainly concerned with modes of feeding, Benthic adaptions are dorsal mouth, barbels, secondary gill-filters, extension of anal fin etc. with a depressed body. Similarly life in fast-flowing hill-streams has its necessary ecological effects e. g. formation of ventral suckers, modifications of pectoral and pelvic fins. The food and feeding shows existence of inches and a principle of coexistence in nature in many fish species.

All this give us a new handle to studies on the optimum conditions to be promoted and maintained in each kind of water with regard to hydrological factors, as also preparation of waters before stocking and the maintenance of suitable conditions for optimum fish-growth.

Social Economy of the Himalayan People in relation to the Forests of Garhwal Himalayas

Raj Kumar Gupta, *French Institute, Pondicherry*

Himalayas are extensively imprtant to India not only geographically but their importance in the economy of the entire country cannot be overlooked. The economy of the Indo-Gangetic plain is dependent upon the socio-economic stability of the Himalayan people. In order to bring fertility to the plains and to utilise in a proper way the flood waters of the Himalayas, it has been considered necessary to build dams and multipurpose valley projects for irrigation, hydro-electric power, flood control and for numerous beneficial effects of these natural resources it has been stressed that mere construction of these dams would not confer the desired benefits. But, in order that the silting of these man-made reservoirs could be reduced the Himalyan structure need necessarily be under vigilance.

The Himalayan slopes become unstable due to earthquake, landslide, landslip caused by deforestation and abuse of land or natural features such as unstable topography, unstable dips and rainfall etc. The forests are related directly or indirectly with the daily life of Himalayan villager with the result that they have become a part and parcel of their life. Without forests the life of a Himalayan villager cannot go on smoothly since he is dependent on the forests for his cultivation, grazing for his sheep and cattle etc. A brief survey of the socio-economic conditions of the Himalayan people have been made, that indicates the closer relations of his daily life with the neighbouring forests. The result is, that, the natural vegetation of oaks is disturbed completely and the conifers take their place at the expense of oaks.

With a view to reduce pressure on the land without disturbing the economic conditions of the Himalayan people some suggestions have been made to develop industries based on the plants, such as

(i) Mat and basket industry

(ii) Resin, gum and dye industry

(iii) Fibre making industry

(iv) Mulberry plantation and sericulture

(v) Lac culture

(vi) Cultivation and exploitation of medicinal plants

Few other suggestions made to improve the economical conditions of Himalayan villager include

(i) Landuse planning

(ii) Pasture management

(iii) Plantation of fruit trees

(iv) Exploitation of forest resources in a proper way for utilising timber and wood for other industrial uses

(v) Development of tourists centres etc.

Ecological Studies in Humid Tropics, Western Ghats

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Humid tropics is distributed in India along (*a*) Western Ghats (*b*) Assam and Bengal and (*c*) Andaman hills. They are characterised by heavy rainfall, high atmospheric humidity and even temperature throughout the year.

Chemical analysis of the soil profiles, from the districts of North Kanara Shimoga and Chikmág Pur (Mysore State) situated along Western Ghats between lat. 13°55′−15°31′ N and long. 74°09′−76°E have been carried out in relation to the communities recognised. Red, black and laterite soil tapes have been recognised in the area. Red soils bear wet evergreen v egetation of *Dipterocarpus, Hopea, Myristica* etc. Teak Bamboo forests occur on Black soils. Laterite supports scrub vegetation of *Gardenia, Glochidion, Eugenia, Ixora* etc.

Analytical data obtained indicates that exchangeable calcium and potassium of soil is related with the vegetation type. Exchangeable Calcium which is lowest in the wet evergreen forest, increases in semievergreen, becomes highest in deciduous vegetation type. On the contrary exchangeable potassium shows the opposite relation *i.e.* it decreases from the wet evergreen to deciduous type.

Autecological Problem of Crop-weeds in India

H. P. Singh, *Gorakhpur*

In India autecological works were confined to trees like *Tectona grandis, Shorea robusta.* However a beginning on herbs was started by Mukerjee on genus *Artemisis.* Afterwards Desai ; Misra and Ral; Srivastava and Tandan; Bakshi and Kapil; Pandeya ; Ramakrishnan; Mall and few others have contributed to the autecology of some weeds. By going through the above literature it is obvious that autecology of crop weeds has been completely neglected although Puri has emphasized the great necessity for doing work on these plants.

All the above mentioned workers have followed the general plan of autecology. Misra and Puri have recommended that the details of autecological works can be varied in each species according to the objective. The objective of studying crop-weed ecology should be to investigate true relationship of crop and weeds and to find out some ecological approach to get rid of them. Hence basides the classical method of autecological study the following important points are put forth for detailed study. These suggestions are the outcome of the work conducted by the author on *Carthamus oxycantha Bieb* (Pohly) during 1959-1960. These points are :

1. Fruiting and flowering time of weed, so that proper time for weeding out may be determined.

2. Edaphic relations if any with this knowledge alternations in soil conditions may be a remedy to control the weeds. *Potentilla supina, Rumex dentatus* are common weeds in new alluvial fields.

3. Dormancy, reproductive capacity and germination.

4. Effect of application of different fertilizer on crop and weeds.

5. Dispersal mechanism and sources of propagules.

6. % loss of crop-yield and effect of crop over the weed.

7. Association of crop and weed. Here the relationship of crop-weed should be known. It may be mentioned that *Orobanchae* is associated with *Brassica alba* and *Carthamus oxycantha* with wheat and gram crops.

8. Type of competition between crop and weed. For this root ecological study will be of much benefit. By such study the author in *Carthamus oxycantha* has noted that there exists no root competition at maturity but shoot competition is quite severe especially with gram crop.

9. Experimental ecology — culture experiments should be performed to confirm the various field data.

Organic Matter and Phosphates In Land Fertility Increase

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Man must recognise the value of organic matter and calcium phosphates aided by sunlight in nitrogen fixation and improvement of humus capital and land fertility without which permanent agriculture is not possible and that artificial fertilizer is no solution of the food problem. I have submitted exprimental results in support of the above contention. Field trials in India and England have shown clearly that crop yields can be increased from 25 to 50% by a mixture of straw and Thomas slag and the yields and the total and available nitrogen in the fields receiving Thomas slag and straw are greater than in lands receiving even 112 lbs of nitrogen as ammonium sulphate. Moreover, alkali lands have been successfully reclaimed for crop production in various parts of India by a mixture of organic matter and phosphates.

From our extensive researches for over 30 years we have come to the conclusion that for intensive cultivation a large dose of organic matter is absolutely necessary for crop production with increasing amounts of chemical fertilizers. I believe that the truth of the above statement is being realised all over the world.

In recent experiments carried on in the U. S. A. by Baum, Heady, Pesek and Hildreth (Iowa State College. Press, 1957) it has been shown that no increase from applications of nitrogen was obtained for rates above 125 lbs/acre. There was some evidence that 188 lbs of nitrogen per acre decreased the yield of crops. Similarly, heavy doses of potash and phosphorus have been found to decrease crop yield.

Prof. K. A. Bondorff, Director, State Laboratory, Lyngby (Denmark) has reported that the consumption of fertilizers in Denmark when increased by 60% , can produce as increase in crop yield to the extant of 4% only and he has unequivocally stated that the possibilities of an increasing use of fertilizers have been overestimated and the law of diminishing return too often neglected.

There is no doubt that the organic matter content of a soil is a fair index of its productive power and durability. It has been frequently observed in different countries that the graph of the yield from increasing doses of nitrogen shows a higher maximum when straw is added than in its absence. The humus content of the Corn-belt lands of the U. S. A. is declining due to inadequate replacement of organic matter and the yield is decreasing in various parts of the world, either the organic matter has been returned to the land in insufficient amounts or humus oxidation has been promoted by too frequent cultivation and application of heavy doses of nitrogenous fertilizers. I found in the Corn-belt area and in other parts that land rich in humus and in possession of a favourable climate formed the basis of crop

production. Moreover, from a scrutiny of the amounts of nitrogenous fertilizers applied and the cereal production of different countries in the world, we have come to the conclusion that in countries not using larger doses of commercial fertilsers, the nitrogen response to cereals is very marked and that the law of diminishing return, too often neglected in modern agriculture by applying heavy doses of commercial fertilizers is in actual operation in countries like Netherlands, Belgium, Norway etc. I believe that next to photosynthesis, fixation of atmospheric nitrogen in soil aided by light absorption is the most important photochemical reaction taking place under natural conditions. The results obtained in India are:

MIDNAPUR (BENGAL) FARM (ON AMON PADDY)

		1958–59	1959–60	1960–61	Average
1.	Control ...	322·40	531·60	816·40	556·80
2.	Organic matter (straw) ...	362·40	762·40	985·20	703·20
3.	Thomas slag (40 lbs P_2O_5/ acre)	350·80	745·20	861·60	652·40
4.	Superphosphate (– do) ...	325·60	682·80	822·00	610·00
5.	Organic matter + Thomas slag	390·00	784·00	974·80	714·80
6.	Organic matter + Superphosphate	399·20	771·60	918·00	696·00

EXPERIMENTS IN SALINE & ALKALINE SOILS OF RAJASTHAN
Organic matter 10 tons/acre and P_2O_5 100 lbs/acre

Grain yield in Kg/acre		Paddy grains	Barley grains
1.	Control ...	45·93	93·75
2.	Organic matter (straw) ...	126·12	175·60
3.	Organic matter + P_2O_5 (as bonemeal) ...	203·91	241·90
4.	Pressmud ...	370·18	266·25
5.	Pressmud + bonemeal ...	501·62	382·50

Studies on the Ecology of Freshwater Fishes of India: Part II

S. M. Das, *Zoology Department, Lucknow University, Lucknow*

In an earlier contribution (1957), the author has given a resume of the work done in Freshwater Fish Ecology in India with reference to work done in the world. Despite the works of Day (1868-89), Hora (1933-53), Mookerjee (1940-54), Das (1935-59), Chacko (1945-59), Alikunhi (1948-58) etc., no quantitative correlations between plankton peaks, pedon peaks and freshwater fisher-growth exists. The present contribution deals with this subject, specially in the lentic waters of Uttar Pradesh. The plankton peaks, pedon peaks and growth in fresh-water fishes are reported in the present paper.

Scale-Studies in Indain Fishes: Part II

S. M. Das, *Zoology Department, Lucknow University, Lucknow*

The first paper (1958) dealt with the types of scales in Indian fishes. The second one deals with the possibility of age determination and interpretation of annuli in scales of freshwater fishes in India. All the scales studied show annuli. The scales of *Anabas, Hilsa, Labeo bata. Cirrihina reba* and *Godusia chapra* have been age-labelled. The singnificance of these annuli in relation to the seasons of the year in India and Europe are compared.

Invasion of Plants in Arid Zones of India

S. K. Jain, *Central Botanical Laboratory, Allahabad*

In India arid and semiarid conditions are met with chiefly in north west in in the states of Rajasthan, Kutch and Saurashtra. It has been suggested with reasonable evidences that about twenty five centuries ago this area supported a flourishing civilization and was richly populated.

Due to various climatic, political and biotic influences the tract has become devoid of good vegetation. Xerophytic flora has gradually established in the area.

Puri, Swarup, Jain and their co-workers studied the flora of these areas and emphasized that due to persistent pressure of biotic factors xerophytic species are spreading in the area.

Recent plant collections of the author from Rajasthan and Kutch have revealed that a number of plants reported earlier only from Arabia and Sind or restricted to small areas in Western Pakistan are now frequently met with in these states.

Examples are *Juncus maritimus* Lamk., *Prenna resinosa* Schan., *Dipterygium glaucum* Decaisne, *Astragalus prolixus* Sieb., *Cassia angustifolia* Vahl, *Heliotropium calcareum* Stocks, *Chrysopogon ancheri* Staph, *Asperagus dumosus* Baker.

The paper describes the localities from where these plants were recorded earlier and cites with reference to herbarium sheets the authors collections of these species from arid zones of India.

Almost all the above noted species are either xerophytes or halophytes and have of recent spread into the arid regions of India.

Further botanical exploration of Rajasthan & Kutch is bound to reveal more plants hitherto unreported from the areas.

A comparison of these floral elements with those of adjacent regions will give useful information on the trend of succession in the habitat conditions of arid zones of India.

Effect of Decomposition of Sal Leaf Litter on Garden and Lateritic Soils

N. K. Jain, *Government College, Guna (M. P.)*

An attempt has been made to study the physico-chemical role of Sal (*Shorea robusta* Gaertn. f.) leaf litter and mature leaves on some soil types. Much work has been done on this line in foreign countries and the role of litter on soil development and maintenance of soil fertility has been recognised. Similar type of study has been recently emphasized in India by Misra and Puri (1954) and Puri (1960). With this knowledge explanations can be offered for the nutrient requirements and distribution of important trees.

In the present investigation replicate pots carrying manured garden soil and red lateritic soil (derived from basalt rocks) were covered with sal leaves. Initial composition of the soils and leaves were determined before setting the experiments. All the pots were watered daily. Every month for a period of one year, soil samples were taken out from the decomposition zone. The samples were analysed for pH, organic carbon, total nitrogen, exchangeable calcium, iron, magnessium and phosphates.

It has been observed that the decomposition of sal leaf litter does not make the soil acidic. This is probably because the sal leaves are not poor in bases. Nitrogen content has been found to increase progressively in the soil below. Most of the basic elements are thus returned to the soil annually making the top soil fairly rich in bases.

The Tasks before the Tropical Ecologist

H. G. Champion, *C/o F.A.O. Regional Office, Phra Atit Road, Bangkok, Thailand*

1. In view of the vast field to be covered, priority should for the present be given to research bearing directly on the major needs of humanity and to the underlying fundamental problems.

2. The most vital problems are now, and will be increasingly in the future, those concerned with the conservation and better use of water, particularly in the wide tracts with continuous deficiency, and all areas with a dry season marked enough to lead to seasonal deficiency.

3. Knowledge of the water consumption of the major tropical types of vegetation, natural, seminatural, or artificial, under different edaphic and climatic conditions and under different cultural and usage treatments, is extremely scanty but is particularly needed as within limits, it is often possible to modify practice in the directions indicated.

4. Chief among these cultural and usage treatments, especially in India, are grazing and burning.

5. Investigation of the effects of differing intensity, kind of stock, and rotational resting, on natural herbage and browse, and on the whole biocoenosis, (including the stock), offers a most interesting field with prospects of great practical utility.

6. The effects of fire on the many vegetation types under different conditions as regards season and periodicity, and their linkage with grazing effects and soil erosion, need much further investigation, especially as regards the humus, moisture, and nutrient content of the soil.

7. In view of the ever increasing areas under irrigation, the effects of varying irrigation regimes on the vegetation and the soil itself, call for much more study, physical, chemical and biological.

8. Linked with irrigation is risk of salination of the soil. More knowledge is needed of the reactions of the biome to this change.

9. The effects of increasing water deficiency on the several components of the biome need closer study, especially on the physiological reactions, competition and adaptation. The genetic aspects are also involved.

10. More studies of the nutrient status of the components of tropical vegetation, with special reference to N and P, with the modern techniques now available, should be very helpful.

11. Recognizing that extremely little vegetation, even in forests hither to believed to be "virgin" now exists that has not been affected directly or indirectly by human activities, there is a lack of knowledge of the potentialities of given sites or vegetation types. The ecological status of even the most familiar types is still a matter of speculation and personal opinion. Extremely little is known of the time scale even where the direction of change is discernible. The present generation should make a special effort to set aside suitable areas for long term study, located where there are the best prospects of excluding interference. Even the methods of recording the present condition and the changes with time are far from agreed; though some form of indicator quadrat seems most promising, there are other methods.

12. Whilst the conditions of the moisture deficient habitats demand prior consideration, the special claims of the vegetation type showing the maximum development known to us, the tropical rain forest, merits much more attention despite the practical difficulties. The limited number of pioneer ecological studies in it serve to reveal how little we know about it.

The Problem of Temperature and Humidity in relation to Tropical Insects

U. S. Srivastava, *Zoology Department, Allahabad University*

The super abundance of insects in the tropics is a problem to the economic biologist. Most tropical insects are sternothermic and live in environments the temperature of which does not go below 15°C some are eurythermic. They show a very high thermal death point and have morphological and behavioral characteristics to avoid excessive heating e. g. metallic or dull colours of the body, rounded shape, and exploitation of favourable microclimates. Inspite of being poikilothermic, they can lower their body temperature below that of the environment by evaporation at the surface. In this matter, size is an important factor. Evaporation depends upon size of body, length of exposure and humidity of air, besides temperature. Another notable feature of tropical insects is their multivoltine nature. Closely related species or the same species found in different parts of the world show this feature clearly. Absence of hibernation, winter diapause and related phenomenon occurring with insects of colder climates causes nearly continuous cycles of development in the tropics; longer and brighter days in winters impart radiant solar energy which is apparently used for metabolism and growth; and the rate of metabolism, following Van't Hoff's law, increases with temperature so that development of each stage and of the entire life history is proportionate to temperature within the effective range, but the law of summation of heat is not precisely applicable. It is also established that variable temperature, in nature, as contrasted with the constant temperature of laboratory conditions is more condusive to development and to lige generally. The occurrence of several crops in the year is extremely useful and a majority of insects is not specific in food habit. The influence of humidity is inseperable from that of temperature and is very variable. The chief effects is through controlling evaporation. Broadly speaking high temperature is most injurious when combined with high humidity for large to moderate sized insects, but high humidity appears useful for small insects. However, individual species must be studied to determine the exact reactions. Their knowledge can be used for control, firstly by forecasting time of emergence, attack, etc.; secondly, while temperature cannot be controlled, the factor of humidity can be used for creating adverse conditions for existence and development.

General Features and Floristic Composition of Tropical Evereen Forests of India

H. P. Bhatnagar, *Forest Research Institute, Dehradun*

The evergreen forests of India has been broadly classified in two broad classes, viz. (1) Southern Tropical evergreen forests (Kerala, Mysore, Madras and Andaman islands) and (ii) Northern Tropical evergreen forests (Assam, West Bengal and N. E. F. A.). They occur on flat or hilly ground upto about 760 meters, extending further up the valleys to about 1060 meters. In western ghats the evergreen forests ascend upto about 1370 meters.

The mean annual temperature lies between 22°C – 26°C. Meen January minimum lies between 10°C – 21°C and in Northern Tropical evergreen forests it is usually about 13°C. Annual rainfall is above 2000 m.m. and rarely below 1500 m.m.

Evergreen forests are characterised by luxuriance of vegetation which may differentiate itself into three or more tiers. The emergent layer is sparse but the

continuous top canopy is dense and consists mainly of lofty trees reaching a height of about 45 meters or mere, often with high plank buttresses. The middle storey consists of evergreen trees, struggling hard for light and the lowest layer consists of dense shrubby evergreen vegetation. The ground cover is very sparse and grasses are very few or absent. The species are very numerous but gregariousness is strikingly absent. There is an abundance of thick stemmed climbers, climbing palms and epiphytes (Aroids, Ferns, Orchids, Selaginella and Lichens). The undergrowth is often a tangel of canes, creeping bamboos and palms. The most common species of evergreen forests of India are as follows :—

TOP STOREY :

Dipterocarpus indicus, D. macrocarpus, D. costatus, Shorea assamica, Hardwickia pinnata, Vateria indica, Artocarpus hirsuta, A. integrifolia, A. chaplasha, Mesua ferrea, Acrocarpus fraxinifolius, Palacuium ellipticum, Poeciloneuron indicum, Hopea parviflora, H. oborata, H. wightiana, Cullenia excelsa, Calophyllum tomentosum, C. elatum, Syzygium spp., Amoora canarana, A. wallichii, Dysoxylum malabaricum, Michelia champaca, Machilus macrantha, Planchonia andamanica, Canarium manii, Kayea assamica, K. floribunda, Heriteria acuminata, Vatica lanceaefolia, Terminalia myriocarpa, Echinocarpus assamicus.

MIDDLE STOREY :

Albizzia julibrissin, Carallia integerrina, Hemicyclia elata, Elaeocarpus serratus, E. tuberculatus, Cinnamomum zeylanicum, C. glanduliferum, Polyalthia fragrans Nephalium longana, Acronychia laurifolia, Cyclostemon macrophyllus, Memecylon caeruleum, Crytocarya ferrarsi, Actinodathne obovata, Turpinia pomifera, Magnolia pealiana, Meliosma simplicifolia.

UNDERGROWTH :

Psychotria truncata, Macaranga roxburghii, Murraya koenigii, Leea sambucina, Strobilanthus callosus, S. ixiocephalus, Helicteres isora, Calamus spp., Callicarpa lanata, Laportea crenulata, Pandanus curcatus, Webera corymbosa, Glycosmis pentaphylla, Pinanga dicksonii, P. gracillis, Saprosma ternatum, Amblyanthus multifolora, Osbeckia spp., Melastoma malabaricum, Alpinia allughas, Calamus erectus, C. flagellum, C. latifolius, Ixora spp.

CLIMBERS :

Entada scandens Bauhinia spp., Gnetum scandens, Tinospora cordifolia, Cocculus macrocarous, Spatholobus roxburghii, Butea superba, Acacia spp., Combretum spp., etc.

Some Important Biotic Factors Opperative in Sal (Shorea Robusta) Forests of Uttar Pradesh

H. P. Bhatnagar, *Forest Research Institute, Dehra Dun*

Biotic factors are amongst the many causes of the failure of natural regeneration of sal in the forests of Uttar Pradesh. The damage done to the forests by forest biota sometimes is quite severe. Activities of men, however, are most destructive. Grazing by domestic animals can altogether change the forest vegetation. Wild animals and insects come next to man, mammels at certain places are the cause of total failure of natural regeneration of *Shorea robusta*. Defoliating insects are also quite destructive specially after forest fires. Climbing and parasitic plants and fungal pests of *Shorea robusta* are also active and they do some damage to the trees.

Polyporus shorea is by far the most destructive. Besides damage, the forest biota are also concerned in doing some good to the forests. Earthworms and many other soil dwellers make soil fertile and porus. Pigs form natural seed beds by digging. Fire also aids to further natural regeneration by reducing floor vegetation.

Germination Studies in Hyptis Suaveolens Poit : Part I : Breaking of Dormancy and Effect of Certain Physical Treatments on the Percentage Germination

M. C. Saxena, *Science College, Raipur (M. P.)*

Hyptis suaveolens Poit belonging to the family Labiatae is an annual to perennial herb widely distributed in Chattisgarh Division. The plant starts flowering and fruiting by October-November.

The seeds of *Hyptis suaveolens* collected during December-January (1959-60) did not germinate soon after and thus showed dormancy. Impermeability of the seed-coat was found to be the main cause of the dormancy. In order to break the dormancy, the seeds were subjected to various treatments both chemical and physical. The present paper deals with the effects of physical treatments on the dormancy and percentage germination of the seeds. The experiments were conducted during January to March, 1960.

The following physical treatment were given to the seeds :

A. Mechanical scarification by removal of testa.

B. Radiant energy—The following radiant energies were given to the dry or soaked seeds :—

   (*i*) Visible light with different durations.

   (*ii*) X-rays.

   (*iii*) Ultra-violet radiations.

   (*iv*) Gamma-rays.

   (*v*) Electric shocks.

   (*vi*) Infrared-rays

C. Different temperatures.

The observations of all the treatments have been described in detail. It has been observed that dormancy of the seeds could be broken by all the physical treatments except infra-red radiations and high temperature treatments.

The percentage germination under different treatments is as follows :

Mechanical scarification by removal of testa — 100%; visible light, alternate 6 hours light and 6 hours darkness - 21%; X-rays with 3 minutes exposure to dry seeds and 30 seconds exposure to soaked seeds – 86% ultraviolet radiations — 26%, with 5 minutes exposure; Gamma-rays – 96 to 100% with 30 seconds to 2 minutes exposures; Electric shocks — 69% with 3 minutes exposure.

High temperature and infrared radiations showed inhibiting effects.

The present studies, therefore, confirm most of the previous results in this direction.

The Place of Biological Control in Forestry Research in India

J. C. Basu Choudhuri, *Forest Research Centre, Coimbatore*

The concept of biological control has very wide applications. Hence, I deliberately propose to refer briefly to its applications (utilising the principles of virosis, bacterial & fungal diseases) and parasitism by invertebrate animals only in the restricted field of folding forest entomology. The method offers special opportunities in forest protection. The advantages are outlined. The results of long terms experiments conducted in this direction in highly industrialized western countries, specially, in the U. S. A., Canada, Germany and Sweden, where forests are vital sources of national wealth, it has been a consensus opinion of the expert forest entomologists that the method of biological control is a new and formidable tool against forest insects.

To elucidate how the parasites of insects have helped in protecting forest and timber resources from the ravages of insects damages some outstanding examples are referred from the world literature.

These examples emphasise that in India we must look forward to intensified research programmes to acquire more knowledge about the ecology of insects and their parasites. To accomplish the task, concerted efforts should be organised to develop long-term comprehensive studies on ecology of insects of forestry and agricultural importance with special to parasitological and pathological studies. Such applied studies will play significant role in the projected national planning to control the damage and wastage caused to our valuable and limited natural resources year after year.

New Approaches to Applied Termitological Researches in India

J. C. Basu Choudhuri, *Forest Research Centre, Coimbatore*

The paper aims to emphasise the importance of the study of termites, from purely scientific and applied aspects.

To fight and eradicate the termite menace we have to arm ourselves with better and improred fighting devices. To achieve this aim it is necessary that we make cencerted efforts in understanding the ways of termites with special reference to agriculture, forestry and other human endeavours from fundamental and applied aspects.

Some suggestions are recorded in this direction in this paper.

The multi-front invasions of termites to unfoil the civilized practices leave no room to doubt for the urgent need of intensified and integrated research programmes to devote ourselves in serious studies of the ubiquitous termites.

Problems of Adaptation among Herbaceous Plants of the Tropics

R. Misra, *Banaras Hindu University, Varanasi*

The nature and mechanism of adaptations as revealed by field observations, culture experiments and analyses of soil and plant in the laboratory with regard to nine herbaceous species are examined and discusssed in the paper. It is shown that adaptations may be structural, physiological and/or developmental and that they arise in response to some of the critical environmental factors as found in the tropical region. The examples of adaptation described in the paper pin point the problems involved in the study and the method of resolving them is shown to be autecological study.

Forestry and Soil Conservation in Maharashtra State

D. V. Khisty, *Conservator of Forests, Poona Circle, Poona*

A brief account of the intimate relation between the Forests and the soil in biological equilibrium together with the disastrous effects of the disturbance of this equilibrium by various biotic factors, leading to accelerated soil erosion has been described. The difference between the Geological Erosion and the Man-made Accelerated Erosion has been brought out, emphasising the need for proper land use for developing the rural economy and the well-being of the country.

2. A detailed account of the geographical and physical features, along with the Forest types and systems of management prevailing in Maharashtra State has been given. The principal problems of soil erosion in the State along with the action taken at present and the recommendations for future line of action on systematic lines have been described. The problems of coastal erosion, stream-bank erosion, river valley catchment erosion in Dry Zone have also been described.

3. The extent of denudation and severe soil erosion in Malki lands as well as in Government forests in the Upper Ghat areas of Western Maharashtra has been described. A brief history of soil conservation and afforestation work has been given.

4. Beginning with the Gradoni type of continuous contour trenching in 1939 to the latest technique of soil conservation and afforestation works has been given. The salient features of the present technique are :

(1) Digging of staggered contour trenches $12' \times 2' \times 1'$ and filling them up with good soil after weathering and giving an inward slope of 1:3 in hilly country.

(2) Digging of pits $1' \times 1' \times 1'$ or trench type pits $2' \times 2' \times 1\frac{1}{2}'$ and filling them with weathered soil with an inward slope.

(3) Construction of *uralies* or contour furrowing on flat or gently sloping land, at an interval of 16' to 20'.

(4) Gully plugging and check damming.

(5) Introduction of hardy tree species and also better quality grasses in the intervening space.

5. A list of hardy species tried in various Afforestation works under different soil conditions along with their planting technique has been described. The importance and the technical aspect of the various methods of soil and moisture conservation measures and the proper choice of species to be planted has been emphasised. Details of average expenditure incurred in Afforestation Schemes are given. A list of Afforestation and Soil Conservation Schemes under implementation in Poona Circle has been appended.

Role of Silviculture in Afforestation with Special Reference to Afforestation Works of Maharashtra State

D. V. Khisty, *Conservator of Forests, Poona Circle, Poona*

The author has briefly explained how Afforestation constitutes essentially as ecological problem and has stressed the urgent need for afforestation in Maharashtra State. The main afforestation problems of the State are :

(1) Afforestation of the open lateritic areas of the west coast, which is being tackled by large scale plantations of Anacardium occidentale.

(2) Afforestation of coastal sand belt which could be takled by raising extensive Casuarina plantations.

(3) Afforestation of the Dry Zone Region.

The present type of Forest and composition of the species and the effect of biotic factors leading to the denudation and accelerated soil erosion has been described. A short history of the evolution of the soil conservation and afforestation technique adopted in the State is given. The present system of Afforestation essentially consists in adopting soil and moisture conservation measures like staggered contour trenching, gully plugging and pit planting. The species prescribed in the various Afforestation Schemes and those actually found suitable by experience together with their technique of planting and tending and the injuries to which they are liable has been explained. Lastly the general silvicultural principles involved in Afforestation operations has been dealt with in detail, under the sub heads soils, Moisture, Closure and Fire Protection, Choice of Species and the Tending and Manurial practices and suitable suggestions have been made for improvement of the Afforestation Technique now adopted in the State.

Forestry and Wild Life Management a Critical Appraisal of their Aims and Ideals

G. S. Bhogle, *Conservator of Forests, Amravati Circle*

Wild life is as much a precious human heritage as the forests in which, it flourishes. Both these heritages need conservation and preservation. Aesthetic value of wild life is no less than that of the forests. Utilitarian value of the forests have laid the foundation of the neglect and retrogression in wild life. (We must reorient our aims and ideals in forestry from the purely materialistic outlook and bring them in consonance with our spiritual and cultural heritage of our great nation). In India we have recently made some efforts at conservation and protection of wild life through enactment and establishment of game sancturies but they are sporadic, disjointed and inadequate.

It has been the impression that scientific forest management is antagonistic to wild life conservation. The creation of pure evenged stands of commercially important species deprives the wild life food and shelter. It is also considered that commercial exploitation with mechanized transport are responsible for diminishing of wild life. In mixed tropical forests any amount of systematic opening will not affect the wild life.

Forests are managed to ensure sustained yield in perpetuity to obtain optimum return from the valuable forests to improve and augment the productivity of forest estate. Wild life can also be managed with the same objects of management. The aims and ideals of wild life conservancy and management are simple and easy to accomplish. The agricultural activities in or around forests are detrimental to the wild life conservation. The crop protection guns are being misused and wild life is being depleted. The working plans casually deal with wild life management very little towards its augmentation. We must provide, if not separate staff, at least additional staff for the wild life management.

Note on Forest and Human ecology

S. S. Buit, *Conservator of Forests, Thana*

Forests and forestry exercise great influence on man and his environment.

Grazing, fires and destruction of forests have affected developement of forests.

The problem of planned forest management has been discussed. It is suggested that heterogenous uneconomic forests should be transformed into economic forests. Forest is a dynamic living association changing in spare and time. Thorough study and knowledge of the component life communities in forest, plant and animal, will determine the course of suitable management.

It is advisable that organisation adequately staffed and necessary scientific investigations are initiated to make available data on the above. This will fill a void in scientific studies confronting us on the important aspect of forestry and human ecology.

SYMPOSIUM ON SPECTROSCOPY

A Symposium on Spectroscopy was organised with Prof. S. N. Ghosh as Convenor, in which the following lectures were delivered :

Speakers	*Title of talks*
Dr. K. Majumdar, Allahabad University	Spectra of diatomic molecules
Dr. P. Venkateswarlu, Aligarh Muslim University	Microwave spectra
Dr. G. B. Deodhar, Allahabad University	X-ray Spectra
Dr. W. M. Vaidya, National Physical Laboratory, New Delhi.	Spectra excited by shock waves
Prof. A. K. Saha, Saha Inst. of Neuclear Physics, University of Calcutta	Spin echo resonance spectra.
Dr. Nand Lal Singh, Benares Hindu University	Spectra of polyatomic molecules
Prof. S. N. Ghosh, Allahabad University	Spectra excited by ion bombardment
Dr. P. Venkateswarlu, Aligarh Muslim University	Neuclear Magnetic Resonance Spectra
Dr. K. Das Gupta, Calcutta University	X-ray Spectra
Dr. G. S. Verma, Allahabad University	Ultrasonics
Dr. Sharda Nand, Allahabad University	Rocket Spectroscopy
Dr. S. Datta Mazumdar, Calcutta University	Theoretical aspects of spectra

SUMMARY OF POPULAR LECTURE

MODERN TECHNIQUES FOR THE ELECTRODEPOSITION OF METALS*

By

A. T. VAGRAMYAN

Electrochemical Institute of the Academy of Sciences, U. S. S. R., Moscow

I am thankful you for inviting me here to take part in the 30th Annual Session of the National Academy of Sciences, India and also for the honour you have given me by asking me to deliver this lecture. We value the Indian Sciences since its development dates back to ancient period. I am grateful for the kindness you have shown to me.

The subject for this evenings talk is "Modern Technique in electrodeposition of Metals." It is necessary to realise that the technique of electrodeposition has developed very rapidly recently. This development has presented many new problems some of which are :—

1. Obtaining high temperature coatings such as used in rockets, and various other machines which work at high temperatures. Such coatings are necessary to minimise the weight as well as the cost.

2. Obtain alloys which are hard and resist wear and tear on rubbing. By using such alloys the machines life can be increased to a very great extent.

3. Many electrolytes used in the processes of electrodeposition are poisonous. One example is potassium cyanide. Such electrolytes are dangerous for the workers and are difficult to dispose off. If thrown carelessly in rivers etc., these can pollute water and kill marine animals. Hence a very essential application of this techniques is in finding new electrolytes which may be non-poisonous.

4. It is these days necessary to find coatings which are corrosion resistant. Often we need to put thin coating which should be free from pores. A thinner coating without loss of resistance proves highly economical since it means saving of large amount of useful metals like nickel, chromium, silver, etc.

5. Sometimes it is necessary to make small tools with difficult shape. These tools may be difficult to make by conventional machines. A useful approach is to take metal powder and compress it at a suitable moderate temperatures into the desired shape.

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* English translation of the lecture delivered in Russian.

6. For newer techniques it is often necessary to use uncommon metals for electrolytic deposition on common metals. Our knowledge of the mechanism of electrode potentials of metals is so hazy that we cannot always know how this deposition takes place.

Detailed investigations of electrodeposition make it possible for us to solve these problems. The electrode processes are usually very difficult and complicated. Many papers have been published on this subject and are being published in connection with the progress of this technique. In this field the subject is growing wider.

Some kind of a more detailed theory about simultaneous discharge of ions for metallic alloy coating has been put by me in a paper whose abstract has been published in the Redox Processes Symposium Bulletin.* The detailed paper will be published in your language in the journal of Hindi Academy of Science (*Vijnana Parishad Anusandhana Patrika*). Those who are interested in this branch can find much interesting knowledge from the articles published on the science of electrochemistry by many Indian workers as well as foreign workers.

I should like to say a few words about work that is being carried out in the electrodeposition laboratory in Institute of Physical Chemistry of the Academy of Sciences, U. S. S. R.

We divide metals in three groups depending on their ease of reduction. The first group consists of metals which are easily reduced such as Sn, Pb, Zn, Ag and Cu. The second group includes metals which are reduced at higher voltage such as Fe, Co, Ni, Mn, Cr and metals of Pt group. The last group is of those metals which cannot be deposited separately for example Mo, W, Zr and Ti. Some of these may be deposited as alloys or simultaneously with other metals. Naturally the question arises why some of the metals are easily reduced while others are difficult to reduce. There are a number of reasons why some metals are reduced with difficulty. Firstly the metal ions may move slowly towards the electrode. Secondly the metal may be strongly aquated and require greater energy in breaking it into the constituents. Thirdly the process of nucleation may require higher energy which results in higher over voltage.

These three reasons are commonly known. Those who base their theories on these conceptions do not pay attention to the surface state and the velocity of electrode processes.

It has been shown in our laboratory that the surface state has a decisive role on the velocity of electrode processes. It has been shown that the surface of an electrode is not uniform but consists of active and passive parts. The velocity of electrode process is not the same on both parts. The velocity of the reaction on the active part of the electrode may be several thousand times higher than on the passive parts. It is easily seen by microscope during the electrodeposition of silver. On the other hand, the character of a reaction depends on the condition of electrode. If an electrode has a non-uniform surface, different reactions may take place at the same time. For example, a solution of potassium dichromate evolves hydrogen on an oxidized electrode. But when the electrode surface adsorbs anion like SO_4, the chromium reduction takes place from hexavalent state to trivalent state.

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* Symposium on Redox Processes, under the auspices of the Chemical Research Committee, Council of Scientific and Industrial Research, held at the University of Allahabad, on February 1 and 2, 1961.

Another example to show that the character of reduction goes very differently depending on the surface condition may be the electrodeposition of manganese. It is well known that it is impossible to reduce a manganous salt, like manganess sulphate in a pure solution. If some ammonium sulphate is added to this solution a part of the current reduces manganous, while the remaining part is used in evolving hydrogen. The efficiency of deposition of manganese depends on the concentration of ammonium sulphate. In absence of ammonium sulphate the total electrode surface remains passive and does not allow the deposition of manganese. The addition of ammonium sulphate makes the surface active and thus allows reduction of manganese.

In the same way it has been shown that the metals of third group may be deposited simultaneously with other metals when we create the active state of the electrode. We can find conditions for electrodepositing the uncommon metals by finding condition of keeping the electrode on a constantly activated state. This concept gives us the opportunity to find a new way for solving the problems of electrodeposition of those metals which have not yet been deposited.

I thank you again for giving me an opportunity to say some words about our laboratory work.

APPENDIX I

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APPENDIX II

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Dr. K. S. Bilgrami

Dr. Rajeshwari Dayal

Dr. Arvind Mohan

Dr. K. Majumdar

Sri S. N. Bhargava

Sri Dinesh Kumar

Sri V. P. Agnihotri

Dr. D. N. Varma

Dr. S. C. Ghosh

Dr. U. S. Srivastava

Dr. S. N. Prasad

Sri R. K. Mehra

Dr. P. N. Srivastava

Sri C. B. L. Srivastava

Sri D. N. Vishnoi

Miss Dipika Kaul

Sri U. S. Kochak

Sri Sri Ram Sinha

Dr. Saeed Hasan

Prof. K. K. Mehrotra

Capt. A. B. Lal

Dr. B. P. Saksena

Sri D. N. Elhance

Dr. P. Ghosh

Sri O. P. Bhatnagar

Sri J. P. Srivastava

Dr. K. D. Vyas

Dr. R. B. Tewari

Dr. S. C. Biswas

Dr. Ramesh Chandra

Dr. Lakshman Chandra

Dr. C. M. Chatterji

Sri O. P. Gupta

Dr. Ram Dayal

Dr. M. D. L. Srivastava

Dr. N. R. Dhar

Dr. B. N. Prasad

Dr. N. K. Sur

Prof. J. K. Mehta

Hon'ble Mr. Justice, V. G. Oak

Dr. P. L. Srivastava

Miss Prabha Grover

Dr. S. B. Adaval

Dr. S. Dutt

Prof. S. N. Chaturvedi

Dr. S. P. Tandon

Dr. S. P. Mushran

Dr. A. K. Dey

Dr. R. D. Tewari

Major R. K. Kaul

Dr. R. C. Kapoor

Dr. Bal Krishna

Dr. R. P. Agarwal

Dr. M. P. Singh

Dr. S. G. Misra

Sri S. S. Uppal

Dr. C. S. Pande

Dr. P. C. Gupta

Dr. Satya Prakash

Dr. S. K. De

Dr. H. L. Nigam

Dr. B. C. Joshi

Dr. B. B. L. Saxena

Dr. G. S. Puri

Dr. R. P. Patil

Dr. J. K. Chaudhury

Dr. K. Lakshminarayana

Dr. S. K. Jain

Major Gujrel

Major Kaul

Sri Lokmani Gupta

Prof. R. K. Varma

Prof. G. R. Sharma

Sri Rajeshji Varma

Mr. Phillips

Dr. D. D. Pant

Sri Jagdish Swarup

Prof. S. N. Ghosh

Sri S. P. Khare

Sri T. L. Venkatesh

Sri K. D. Dikshit

Sri M. S. Bist

APPENDIX III

LIST OF DELEGATES

FOREIGN

U. S. A.

Dr. D. C. Rife

Mrs. D. C. Rife

U. S. S. R.

Dr. A. T. Vagramyan

INDIAN

Dr. A. C. Saxena

Dr. C. B. L. Varma

Dr. S. C. Chakravarty

Dr. P. K. Mukherjee

Dr. K. C. Bose

Dr. L. N. Jauhari

Sri O. N. Bhardwaj

Sri S. L. Rai

Dr. R. N. Singh

Dr. D. B. Saxena

Sri N. K. Jain

Dr. S. C. Pandeya

Dr. P. D. Pathak

Sri B. Biswas

Dr. J. S. Dave

Dr. U. N. Chatterji

Dr. H. A. Khan

Dr. G. P. Agarwal

Dr. S. Bose

Dr. S. P. Srivastava

Dr. Y. K. Gupta

Dr. R. S. Singh

Dr. B. C. Sinha

Dr. K. Swarup

Dr. O. N. Tripathi

Dr. N. L. Singh

Dr. R. M. Bhatnagar

Dr. A. C. Chatterji

Dr. A. S. Ghosh Mazumdar

Dr. O. N. Perti

Prof. R. Misra

Shri Kuldip Singh

Dr. S. M. Das

APPENDIX IV

LIST OF MEMBERS AND FELLOWS

[Completed upto 1st June, 1961]

(Names of Fellows are marked with *; and of Life Members with †)

Abdi, Wazir Hasan, M.A., Research Scholar, Dept. of Mathematics, Lucknow University, Lucknow.

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Agnihotri. Virendra Prasad, M.Sc., Research Scholar, Botany Dept., University of Allahabad, Allahabad.

Ahluwalia, S. S., M.V.Sc., Research Officer, U. P. College of Veterinary Science, Mathura.

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Ballabh, Ram, M.Sc., Ph.D., Professor and Head of the Department of Mathematics, University of Lucknow, Lucknow.

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*Bhattacharya, Abani K., D.Sc., F.R.I C., Professor and Head of the Department of Chemistry, Agra College, Agra.

Bhattacharya, A. P., M.A., Research Officer, Basic Research Division, Irrigation Research Institute, Roorkee.

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*†Ghosh, S. C., M.Sc., D. Phil., Assistant Professor of Zoology, University of Allahabad, Allahabad.

*†Ghosh, S. K., M.Sc., D.Phil., Assistant Agricultural Chemist to the Government of West Bengal, State Agricultural Research Institute, 230 Netaji Subhas Road, Tollygunge, Calcutta-40.

*†Ghosh, S. N., D.Sc., Professor of Applied Physics, J. K. Institute of Applied Physics, University of Allahabad, Allahabad.

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Gupta, A. C., M.Sc., Head of the Department of Chemistry, Janta College, Bakewar (Etawah).

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Johri, L. N., D.Sc., Reader in Zoology, University of Delhi, Delhi-6.

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†Mathur, P. B., M.Sc., D.Phil., Senior Scientific Officer, Central Electrochemical Research Institute, Karaikudi-3 (S. India).

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